The Association Between Functional Social Support and Memory: A Prospective Analysis of the Canadian Longitudinal Study on Aging

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Identifying modifiable psychosocial factors that influence age-related outcomes is important for healthy aging. Functional social support (FSS), or the perceived availability of support from others, appears to delay memory loss via biological and psychological pathways. However, due to the complexity of measuring FSS, evidence is limited regarding its association with memory. Objective of this thesis was to identify an association between FSS and change in memory using baseline and 3-year follow-up data from the Comprehensive Cohort of the Canadian Longitudinal Study on Aging (CLSA), an ongoing cohort study of adults aged 45-85 years at baseline.

FSS was measured via the Medical Outcomes Study–Social Support Survey (MOS–SSS); immediate and delayed recall memory were measured with the Rey Auditory Verbal Learning Test I and II, respectively. The RAVLT I and II z-scores were averaged at each time point to compute a combined memory z-score. Multiple linear regression was used for the analysis. The difference between the combined baseline and combined follow-up memory scores was regressed on the FSS variables (overall and four subtypes), which were categorized into high (scores ≥ 4) or low (scores ≤ 3), while controlling for baseline memory scores, sociodemographic variables, health variables, and lifestyle variables.

The analytic sample comprised 12,011 participants (mean age = 61 years). The participants reported high levels of FSS (overall FSS: weighted mean = 4.34 out of 5.00 [standard error = 0.01]; weighted median = 4.46 [interquartile range = 0.88]). Fifty-seven percent of the weighted sample reported declines in combined memory scores over three years.

Regression models indicated weak yet generally positive associations between overall and subtypes of FSS and positive changes in memory score over three years, although most regression coefficients were not statistically significant ($\alpha = 0.05$). No clear pattern of effect modification was identified across the age and sex groups in stratified regression models.

CLSA participants were cognitively stable and most reported a high level of FSS, which likely contributed to the weak and non-significant associations between FSS and change in memory scores. A substantial attrition of participants with RAVLT measurements may also have contributed to the lack of significant associations. Longer follow-up of the CLSA sample is likely required to further assess this association.

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But he knows the way that I take;
when he has tested me, I will come forth as gold.

Job 23:10

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ADL	Activities of Daily Living
AFF	Affectionate Support
APOE	Apolipoprotein E
CES-D10	Center for Epidemiological Studies Short Depression Scale
CI	Confidence Interval
DCS	Data Collection Site
EMI	Emotional/Informational Support
FSS	Functional Social Support
IADL	Instrumental Activities of Daily Living
IQR	Inter-Quartile Range
LSNS	Lubben Social Network Scale
MCI	Mild Cognitive Impairment
MMSE	Mini Mental State Examination
MOS-SSS	Medical Outcomes Study – Social Support Survey
NuAge	Quebec Longitudinal Study on Nutrition and Aging
OR	Odds Ratio
POS	Positive Social Interactions
RAVLT	Rey Auditory Verbal Learning Test
RDD	Random Digit Dialing
SD	Standard Deviation
TAN	Tangible Support
WAIS-R	Wechsler Adult Intelligence Scale – Revised
WMS-R	Wechsler Memory Scale – Revised

1.0. Literature Review

1.1. Healthy Aging

Aging is a natural, irreversible, biological process in which molecules undergo structural disintegration and compromise cell and organ functions.[1] Aging renders individuals susceptible to infections, inflammation, and reduced functional capacity in areas such as mobility and employment, leading to medical, social, and economic complications. A recent global survey reported that aging accounts for 51.3% of the total disease burden among the global adult population.[2]

Despite sometimes negative public perceptions, aging is not necessarily synonymous with poor health. Healthy aging is defined as "the process of developing and maintaining the functional ability that enables wellbeing in older age"[3] or "having a capacity to remain resilient and adaptive to increasing challenges from one's mind and body."[4] Biological and psychosocial factors can influence mental and physical health in aging persons: an important focus of aging research is to uncover risk and protective factors for healthy aging.

Individual trajectories of aging vary greatly due to differential experiences with adversities throughout life, e.g., acute or chronic health issues, economic deprivation, psychological trauma. Studies show that prolonged exposure to various adverse life events can modify stress-response mechanisms and impact brain structures involved in aging, leading to problems with cognitive function.[5]

1.2. Cognitive Function

Cognition is broadly defined as the mental ability involved in thinking, understanding, learning, remembering, problem-solving, and decision-making.[6] This ability is essential for

living, working, relating with others, and thriving in communities. Cognition includes all activities of perceiving, reasoning, remembering, analyzing, paying attention, creating/synthesizing ideas, and making judgments.[7] These activities inter-relate to form a complex and multidimensional process[8] that is crucial for daily functioning and healthy aging.

With regard to aging, cognitive ability influences functional independence, self-perceived well-being, and quality of life.[9] However, brain regions that are critical for cognitive functioning, such as the hippocampus and neocortex, are susceptible to the effects of aging.[10] Conservative estimates suggest the global prevalence of minor and major neurocognitive disorders in the aged (65 years or older) is between 5.0 to 36.7% and 1.2 to 7.2%, respectively.[11] A study led by the Alzheimer Society of Canada[12] reported that approximately 564,000 Canadians were living with major neurocognitive disorder in 2016; the study projected this number would grow by 66% to 937,000 in 2031. A major public health goal is therefore to identify demographic, biological, and psychosocial factors that can help preserve cognitive function in aging individuals.[13]

1.2.1. Domains of Cognitive Function

Six domains of cognitive function are listed in the Diagnostic and Statistical Manual of Mental Disorders (5th Edition): (1) learning and memory (free recall, cued recall, semantic and autobiographical long term memory, implicit learning); (2) executive function (planning, decision-making, inhibition, flexibility, working memory, and responding to feedback); (3) perceptual-motor function (visual perception, visuo-constructional reasoning, perceptual-motor coordination); (4) language (naming, word finding, fluency); (5) social cognition (recognition of emotions, insight); and (6) complex attention (sustained attention, divided attention, processing speed).[14] Taken together, these domains form what researchers call ‘global’ cognitive function.

1.2.2. Memory

This thesis focuses on the memory domain. Memory is typically classified into four types:[15] episodic, semantic, implicit, and working memory. Episodic memory refers to an ability to actively retrieve personal experiences in personal contexts; semantic memory refers to holding a structured record of facts, concepts, and knowledge about the external world; implicit memory refers to recalling past experiences without conscious effort (e.g., riding a bike); and working memory refers to storing and using information for short time periods.[15] Free recall and cued recall functions belong to the non-verbal retrieval skills of episodic memory,[16] which also include non-verbal encoding, non-verbal storage, and verbal subtypes. As such, memory supports many facets of life: maintaining relationships, performing job functions, putting things into context, and ultimately maintaining functional independence. While memory loss is often considered to be a natural part of the aging process,[17] memory impairment extending beyond a certain point is not a part of normal aging, and is linked to increases in the risks of minor and major neurocognitive disorder, institutionalization, and mortality.[18]

In fact, much age-related cognitive decline is reported to be specific to memory function, compared to visuospatial ability, language, and abstract reasoning.[19] The specific impact of aging on memory is explained by deteriorations in the hippocampus[19] and prefrontal cortex[20] over time. Episodic memory has been reported as one of the first domains compromised in cognitive decline[15,21,22] and its decline is associated with progression to Alzheimer's disease.[22,23] Problems with episodic memory materialize in the form of difficulty encoding new information into memory and retrieving this information shortly afterward,[19,23] e.g., being unable to remember one's latest family trip or making simple mistakes performing once-familiar tasks. Impairment of episodic memory can lead to feelings of uncertainty, irritation, frustration, fear[24] and

depression.[25] Working memory is another domain of memory that has been reported to decline substantially with age.[26,27] Decline or impairment in working memory affects performance of daily tasks (i.e., reading, writing, making plans)[27] and increases distraction.[28]

1.2.3. Cognitive Decline

Cognitive decline with age can affect a single domain such as memory, or multiple domains simultaneously, and can occur on a continuum from minimal to severe.[14,29] 'Normal' cognitive decline varies considerably across people[30] and is thus best determined by the historical context of each individual.[19,30,31] Normal, age-related cognitive changes are small and do not result in impairment of daily functions. Some cognitive skills, such as vocabulary, are resilient to brain aging, but other abilities, such as memory, processing speed, and abstract reasoning, may decline over time.[31]

Mild neurocognitive disorder, or "mild cognitive impairment" (MCI), is a progression away from normal cognitive decline yet does not undermine an individual's ability to perform activities of daily living,[32] although the activities may be performed at suboptimal levels and may require more effort.[14] A common criterion for diagnosing mild neurocognitive disorder is the presence of deficits in one or more cognitive domains, with or without memory impairment, and no loss of independence in daily living.[14]

Major neurocognitive disorder, or "dementia", is largely distinguished from the mild type by a progressive loss of functional independence, with individuals ultimately losing the ability to perform basic and instrumental activities of daily living.[14] Alzheimer's disease (AD) is the most common form of major neurocognitive disorder, and it is characterized by progressive and substantial deficits in at least two cognitive domains, most typically learning and memory.[14]

Although 10% to 15% of individuals with mild neurocognitive disorder are likely to progress to major neurocognitive disorder every year,[32] the progression is "neither inevitable nor uniform."[29] This may be explained by the high level of heterogeneity among persons with mild neurocognitive disorder.[29,33] Progression rates vary by age and sex, among other factors, with higher rates in older persons and females,[33] and higher rates also seen in clinic- versus population-based studies.[34 29]

1.2.4. Risk and Protective Factors for Cognitive Function

While the greatest risk factor for declines in cognitive function over time is reported to be age,[35] a number of biological, lifestyle, psychosocial, and sociodemographic factors have also been shown to adversely affect cognitive function.

1.2.4.1. Biological Factors

A number of genes and hormones are associated with the onset of cognitive decline, or the progression from milder to more severe forms of cognitive impairment, including Apolipoprotein E (*APOE*)-ε4 allele,[36–41] Sortilin-related receptor (SORL1) gene,[36,40] brain-derived neurotrophic factor (BDNF),[32,37,39] phosphatidylinositol-binding clathrin assembly protein (PICALM),[40] complement receptor 1 (CR1),[40] bridging integrator 1 (BIN1),[40] and translocase of outer mitochondrial membrane 40 (TOMM40) genes.[40]

APOE-ε4 has been most widely studied and most strongly associated with the onset of Alzheimer's disease.[33,34,37,38] The presence of *APOE*-ε4 is associated with a higher burden of Aβ peptide deposited in the brain,[36,41] which reduces synaptic plasticity and memory deficit.[32] The presence of *APOE*-ε4 is associated with faster age-related loss of hippocampal volume compared to those without the allele, and is linked to hippocampal damage in individuals with Alzheimer's disease.[41,42] The under-expression of SORL1 gene results in directing of the amyloid precursor

protein (APP) to recycling pathways, which increases the risk of cognitive impairment.[36] BDNF is involved in long-term potentiation in hippocampal neurons and plays a critical role in learning and memory.[37] Other genes under study include alpha1-antichymotrypsin (ACT), cholinergic receptor (nicotinic alpha 7, CHRNA7), peptidylprolyl cis-trans isomerase (PIN-1), transforming growth factor-beta 1 (TGF-beta), vascular endothelial growth factor (VEGF), a member of the cytochrome P450 superfamily (Cyp46A1), and nitric oxide synthase 3 (NOS3).[36]

Estrogen – specifically bioavailable estrogen levels, not total estrogen levels[43,44] – has been reported by many studies to have protective effects on cognitive function in men and women.[45–47] Underlying mechanisms for the neuroprotective effect of estrogen are considered to be promotion of the growth of cholinergic neurons, anti-oxidation, and promotion of non-amyloidogenic metabolism of the amyloid precursor protein.[44] However, the evidence has been inconclusive in some studies,[48] showing inconsistency particularly among older populations.[44] Somatotrophic hormones such as growth hormone-releasing hormones (GHRH) have also been found to enhance cognition or slow down age-related cognitive decline[49–52] by supplementing depleted growth hormones, levels of which are associated with learning and memory performance.[52]

Clinical studies have also identified associations between several health conditions and increased risks of cognitive impairment, including cardiovascular conditions such as hypertension,[53–56] hypotension,[53,54] diabetes,[53,56] heart attack,[53–55] angina,[53,54] coronary artery disease,[55] atherosclerosis,[55] hyperlipidemia,[56] and atrial fibrillation.[54,55] Additional risk factors include stroke and other cerebrovascular conditions,[53–55] traumatic brain injury,[54,56] lack of sleep,[56] and sensory impairment.[53] Many of these health conditions are also associated with the lifestyle and psychosocial factors discussed below.

1.2.4.2. Lifestyle Factors

Lifestyle risk factors associated with poor cognitive function include physical inactivity,[56] smoking,[56] excessive alcohol use,[56] and fatty diets.[56] Mid-life obesity has also been reported to increase the risk of cognitive decline.[56] Conversely, evidence suggests that physical activity can benefit cognitive function by stimulating brain functions such as cortical plasticity.[55] A diet rich in fruits, vegetables, fish, nuts, and olive oil may help reduce the risk of cognitive decline,[56] although the literature on diet and cognitive function reports conflicting findings.[56]

1.2.4.3. Psychosocial Factors

Psychosocial risk factors for cognitive decline have been relatively less studied compared to biological and lifestyle factors. The existing literature largely focuses on depression, stress,[57] and social environments/engagement.[32] For example, loneliness and the psychological stress arising from it have been found to be associated with elevated cortical amyloid in older adults, which is a risk factor for cognitive decline.[32] Less social contact has also been identified as a risk factor for dementia.[58,59] Increased social support has been cited as a potential buffer against cognitive loss in older adults,[56,57] along with years of formal education[56] and other forms of cognitive stimulus (e.g., religious participation[60]). The influence of social support on cognitive function will be discussed in subsequent sections.

1.2.5. Measurement of Cognitive Function

A wide variety of question- or task-based instruments are used to measure global, and specific domains of, cognitive function. A commonly used instrument in clinical and research settings is the Mini Mental State Examination (MMSE),[61] which tests global cognitive function, time and space orientation, short and long-term memory, oral language ability, subtraction skills, and sentence formation. Other scales of global cognitive function include the Brief Test of Adult

Cognition by Telephone (BTACT),[62] Cambridge Cognitive Examination (CAMCOG),[63] Wechsler Adult Intelligence Scale (WAIS),[64] Repeatable Battery for the Assessment of Neuropsychological Status (RBANS),[65] and Telephone Interview for Cognitive Status (TICS).[66]

Many other assessment instruments have been developed to measure specific cognitive domains. For example, memory tests include the Rey Auditory Verbal Learning Test (RAVLT)[67] and East Boston Memory Test (EBMT);[68] executive function tests include the Mental Alternation Test (MAT),[69] Controlled Oral Word Association Test (COWAT),[70] Stroop Test,[71] and Prospective Memory Test (PMT).[72]

In aging research, tests of memory and executive function are commonly used to assess cognitive decline. This is so because memory is one of the first functions compromised as people age[22,37] and executive function involves higher order mental processes (e.g. mental flexibility, problem-solving, self-regulation, and reasoning) that directly influence independent daily living.[73]

1.3. Social Support

1.3.1. Types and Definitions

'Social support' broadly refers to the social resources individuals can use to help with decision making, problem solving, and maintaining positive experiences in life.[7] Multiple terminologies exist to describe various facets of social support, including social engagement, social integration, social activity, and social relations.

Conceptually, social support has structural and functional aspects.[74] Structural social support refers to the size of social networks, the frequency of social contacts, and the extent to which individuals participate in social events outside of the home. Functional or perceived social

support—the focus of this thesis— concerns the substantive nature of social relationships, that is, the presence of confidants, availability of practical help and emotional support when needed, and the satisfaction derived from social relationships. Functional social support (FSS) is also defined as "the extent to which individuals may draw upon other persons and communities for help, care, and comfort in times of need."[75]

1.3.2. Structural and Functional Social Support and Health

Research on the relationship between social support and physical health dates back to 1979, when Berkman et al. reported an inverse relationship between social ties and mortality in a 9-year follow-up of 6,928 adults in the United States.[76] A large number of studies have since reported that higher levels of social support predict better overall physical and cardiovascular health,[18,55,76,77] and protect against coronary heart disease,[18,54] cancer,[77] high blood pressure,[18,77] functional decline,[54] and depression.[54] Higher social support is also inversely related to infectious disease mortality[77] and overall mortality.[7,18,54,76,78,79]

Berkman et al.'s findings have been echoed by a so-called "second wave"[80] of evidence investigating the health impacts of FSS, including marital quality, perceived social support, and satisfaction with social support received. The evidence shows that higher FSS is inversely related to all-cause mortality,[81,82] cardiovascular morbidity[18,81–83] and mortality.[78,82,83] More specifically, emotional support protects against cardiovascular mortality among older individuals,[78] buffers the impact of stressful life events on the risk of depression and depressive symptoms in older adults,[4,80] and promotes overall mental health in young and middle-aged adults.[84]

Uchino[77] illustrates three potential biological mechanisms through which functional social support influences overall health: cardiovascular, neuroendocrine, and immune system. The cardiovascular mechanism explains that stressful life events, including stress arising from

social relationships, results in high levels of cardiovascular reactivity (e.g., elevated blood pressure or heart rate), which in turn increases the risk of cardiovascular disease. FSS, in the form of warmth and encouragement from one's social network, can alleviate such stress, reduce cardiovascular reactivity, and lower the risk of cardiovascular disease ("stress-buffering theory").[77,85]

The second of Uchino's mechanisms, the neuroendocrine mechanism, focuses on hormones and neurotransmitters that mediate cardiovascular and immune functions. Clinical evidence suggests high levels of social support are associated with reduced levels of catecholamine and cortisol, which are known to suppress immune function.[77] Reports also indicate perceived positive social support is associated with oxytocin release, which reduces cortisol and blood pressure during stress, and has further anti-stress effects in the brain and peripheral systems.[77]

Uchino's third mechanism, the immune mechanism, is supported by evidence that social support predicts stronger activities of natural killer cells in tumor-infiltrating lymphocytes, as well as increases in helper T-cell counts.[74,77] Stress from the social environment, caused by a lack of social support, has been reported to increase oxidative stress and inflammatory reaction,[32] as well as Epstein Barr Virus (EBV) antibody titers.[80] While more research is needed to make firm conclusions, preliminary findings thus far show that social support may play an important role in boosting immune functions against cancer, influenza, HIV, and hepatitis B.[77] Social support and its influence on cognitive health is presented in Section 1.4.

1.3.3. Factors that Influence Structural and Functional Social Support

1.3.3.1. Age

Structural social support typically declines with age, as individuals experience adverse health conditions, limited mobility, and loss of loved ones. These experiences lead to reductions in social networks and fewer opportunities for social participation.[6,9,86,87] However, reduced structural social support in older age may be counterbalanced by increases in the quality of social ties, or higher FSS. As socioemotional selectivity theory suggests,[18,88,89] individuals shed less important social relations over time and concentrate on meaningful and beneficial relations. This explanation is buttressed by the convoy model,[90] which states that individuals' social relations fluctuate throughout the life course,[91] but the overall level of social support (structural and functional combined) remains stable across the lifespan."[18]

Some empirical studies of FSS in older individuals report low or declining levels of support over time,[6,92] while other studies report stability over time.[4,18,79] Age may also modify the association between the quality of social support and cognitive function. A recent study reported that the association between poor FSS and cognitive decline was stronger in older compared to younger individuals.[93] Although the underlying mechanism between low FSS and cognitive impairment is not clear, individuals' predisposition to perceive FSS as poor or inadequate may contribute to higher accumulated exposure to stress over time for older individuals.[93]

1.3.3.2. Sex

Sex appears to moderate the association between FSS and cognitive function.[92,94] A high level of FSS was found to be associated with higher global cognition for older men, but with low global cognition for older women over nine years.[92] Two cross-sectional studies also reported

that the association between FSS and cognition was stronger for men compared to women.[95,96] These findings are contrasted by two other studies, in which women cognitively benefited more from high levels of FSS compared to men.[94,97]

Women and men perceive and engage in social relationships in a fundamentally different manner,[94,98] with women typically drawing upon larger, more complex, and multi-faceted social networks, and receiving more support from diverse social ties. Conversely, men tend to maintain smaller networks and focus on their spouses.[79,89] Studies show that women draw more satisfaction,[79,92,98] as well as strain,[99] from large and diverse sources of social support, which may be explained by the fact they also provide more support to their social ties than men.[79]

As well, the effect of spousal support on cognitive function seems to differ across both sexes. Higher spousal support is associated with better cognitive function at baseline, and slower cognitive declines over time, in men. Conversely, these associations are far more muted in women.[92] In general, men tend to rely on their spouses for social support,[74] while women rely on relationships with children and friends.[79,92]

1.3.4. Measurement of Structural and Functional Social Support

Studies that measure structural social support often ask participants about their marital status, living arrangements, number of close ties with children, number of persons in their social networks, and the frequency of participating in community activities. The Lubben Social Network Scale (LSNS)[100] is commonly used to assess the structural aspect of social support, and it measures the presence of social contacts, size of the social network, and social isolation. Measures of FSS, on the other hand, ask participants about the presence of affectionate and emotional support, availability of reliable help to perform personal tasks, and satisfaction with support. The Medical Outcomes Study – Social Support Survey (MOS-SSS),[101] for example,

asks about perceived social support across four subscales: emotional/informational support (having someone with whom to share private worries), affectionate support (having someone who shows love and affection), tangible support (having someone to help with daily tasks if needed), and positive social interactions (having someone with whom to share good times).

No gold standard exists for measuring structural or functional social support and many research groups develop their own questionnaires or modify existing tools to meet their needs. This has resulted in discordant findings in the literature.[54,102]

1.4. Structural and Functional Social Support and Cognitive Function

A literature review was conducted to explore the relationship between social support (both structural and functional) and cognitive function (all cognitive domains). An expansive review was undertaken in light of the variability observed in the literature with regard to the definition and measurement of social support.

A systematic literature search for human studies was conducted using PubMed and PsycINFO, first in January 2020 and updated in March 2021. The search scope began at database inception. The search terms were related to social support and cognition, and are shown in Appendix A. The methodology filter for quantitative studies was used to help identify relevant citations in PsycINFO. The search retrieved 3,850 articles in PubMed and 232 in PsycINFO. The citations were filtered by age, population, and methodology: studies on individuals aged younger than 45 years, caregivers, or studies that used qualitative methodologies were excluded. Articles studying social support or cognitive function as exposure or outcome variables using cross-sectional or longitudinal approaches were included. Further screening resulted in 45 articles relevant to the topic (Appendix A). A search of the reference lists of included articles added 7

articles, resulting in 52 articles for the literature review. All 52 articles are summarized in tabular form in Appendix A.

1.4.1. Structural Social Support and Cognitive Function

Structural social support has received far more attention in the literature than FSS.[7,54] Despite conflicting evidence on the magnitude of effect,[86,103] supportive social networks are usually protective against cognitive decline.[98] A recent review of 21 studies undertaken in samples of older adults reported that higher levels of structural support (mostly measured as frequency of social activities) were positively associated with better cognitive function.[7] Indeed, reduced frequency of social interactions has been shown to be associated with a higher risk of cognitive decline over time among older adults.[9,55] Conversely, diverse sources of social support, rather than single sources, may substantially reduce the risk of cognitive decline over time in adults aged 65 years or older.[74]

1.4.2. Functional Social Support and Cognitive Function

Many researchers challenge the emphasis on structural social support because they believe the quality of support is more important than the quantity of social contacts.[86,104] The English Longitudinal Study on Aging (ELSA, 2002-2010) recently conducted an eight-year investigation of the association between the perceived quality of social support and cognitive function among 10,241 community-dwelling individuals aged 50 years or older.[92] The authors observed that higher positive social support (feeling understood, able to rely on someone for help with problems, and knowing someone to whom one may ‘open up’ to) predicted better cognitive function and slower memory decline. These results echo the findings from an earlier longitudinal study (Rush Memory and Aging Project) of 529 community-dwelling individuals, also aged 50 or over, which showed that negative social support, characterized by conflict, tension, or

criticism, was positively associated with mild neurocognitive disorder and lower levels of function on all cognitive domains over four years.[93]

Indeed, a majority of studies, including the MacArthur Studies of Successful Aging,[57] reported that higher levels of FSS predicted higher global cognition. Thirty-two (including three systematic reviews) out of 42 studies investigating the association between various forms of FSS and cognition in cross-sectional or longitudinal designs confirmed these positive associations. Emotional and informational support, in particular, have shown stronger associations with higher cognitive performance[18,23,24,30,33,36,38–43] than other subtypes of FSS.

The greatest protective effects for emotional support were observed among individuals aged 65 years or older.[107,108] Higher satisfaction with social support, or higher perceived social support, was found to be associated with higher cognitive function both globally and among several cognitive domains,[109] while frequent negative social interactions were reported to be a potential risk factor for cognitive declines in old age.[92,93,110] The association between low FSS and the risk of cognitive decline was strongest among older rather than younger individuals.[93] A decrease in instrumental support and positive social interactions predicted cognitive decline.[111]

A few studies found inverse associations between FSS and specific cognitive domains. For example, two studies of American older adults reported that conflicts and strains from relationships were associated with better episodic/working memory[105] and executive function.[105,109] The solidarity-conflict model[112] provides one possible explanation for the findings in these two studies. This model postulates that functional support and strain/conflict co-exist in close relationships and illustrate cohesion among members of a group. The ‘ups and downs’ of interpersonal relationships provide a degree of cognitive stimulation that preserves cognitive function. Alternatively, the contrasting findings of these two studies, compared to the positive

associations found in other studies,[92,93] may be explained by limitations of the studies with respect to design and sample: the first of the two studies (n = 3,159) was cross-sectionally designed and conducted on one ethnic group in one city, while the second was a five-year study of a small sample (n = 217) dwelling in one county in America.

Tangible social support was found to be unrelated or negatively related to cognitive function in three studies,[89,97,107] potentially because tangible support involves a less nurturing and more controlling nature (e.g., giving instructions), and often includes interactions with paid support workers rather than close personal relatives, friends, etc.[82,89] Another explanation for the null or inverse findings could be that people who depend on tangible support had other health conditions undermining cognitive function.[89] In fact, one study found significant negative associations between perceived social support and cognitive function among individuals with chronic illnesses or disabilities.[113,114]

Studies focused on the providers of functional social support yielded varying results. While one study found that lower perceived social support from friends (as opposed to family) was significantly associated with lower executive function,[105] another study reported that higher perceived social support from family significantly and negatively predicted vocabulary and global cognition.[89] Weiss, in his functional-specificity model,[115] explained that one's need for a specific type of support can be optimally met by certain individuals, whereas the same type of support, if provided by someone else, might not have the same effect.

For older individuals, family (as opposed to friends) appears to be an important source of emotional social support. Simons'[116] American cross-sectional study of 299 community-dwelling adults aged over 65 found that feelings of security can most effectively be fulfilled by spouses and children, and sense of intimacy can be most effectively provided by spouses. These findings

were supported by Felton et al.,[117] who identified that stress-compensating functions were most effectively provided by kin than non-kin.

1.4.2.1. Functional Social Support and Memory

Specifically for the memory domain, eighteen relevant studies (including one systematic review) were retrieved in the literature search; all except three[57,118,119] reported positive associations between FSS and memory. A high level of perceived social support in the United States, United Kingdom, and France predicted delays in memory decline in longitudinal studies of adults aged 50 years or older,[18,93] with effects seen in episodic memory,[6,63,76,106, 108] working memory,[95,120] and delayed spatial recognition.[121] A nation-wide, cross-sectional study of Japanese adults aged 65 years or older also reported an association between social support (both structural and functional) and lower levels of forgetfulness.[122] A recent systematic review of 39 studies on community-dwelling older adults identified that functional, as opposed to structural social support, was positively associated with episodic memory.[86] Higher emotional and informational support was positively associated with overall memory in adults aged 19 and older, [89] and episodic memory in adults aged 60 or older.[105,109]

Other studies also reported associations between lower satisfaction with social support and declines in episodic memory over time among older adults.[6,109] A possible explanation is that chronic stress arising from poor social support leads to permanent loss of hippocampal neurons[123,124] and structural damages to the hippocampus,[54,125]which governs memory functions. Indeed, in an American longitudinal study of 529 adults aged 50 years or older, a higher mean negative social interaction score was associated with faster declines in episodic, semantic, and working memory.[93]

The authors of the three studies reporting non-significant associations, all of which examined community-dwelling older adults (two cross-sectionally and one longitudinally), explained their findings differently: participants' higher-than-expected performance on the RAVLT eliminated the possibility of finding any effect;[119] a misalignment existed between the subtype of FSS examined in the study (emotional and tangible supports) and the support needs of recipients;[57] or, FSS had a lesser impact on memory compared to general cognition and processing speed in a principal components analysis used to generate cognitive scores.[118]

1.4.3. Factors that Moderate the Association between Social Support and Cognitive Function

Many studies have examined whether age and sex modify the association between social support and cognition, but the results are inconclusive. Seeman et al.[6] reported a weakening yet positive association between social support (both structural and functional) and cognitive function as age increased, while Wilson et al.[93] observed that the association between a low level of FSS and the risk of cognitive decline was stronger among older individuals. Ohman[96] reported that the association between FSS and memory was strongest among the age groups of 45-54 years and 75 years or older compared to groups of 55-64 years and 65-74 years. Oremus et al.[75] and La Fleur et al.[89] reported that age did not modify the association, which supported Ertel et al.'s[18] finding that overall levels of social support remained largely stable over time.

Sex, on the other hand, was reported to moderate the association between both structural and functional social support and cognitive function in many studies,[18,85,87,93,94,110, 116-118] with the positive association between high FSS and better cognition being stronger in females compared to males. However, a cross-sectional study of the Canadian Longitudinal Study on Aging (CLSA) Comprehensive Cohort at baseline[96] observed that delayed recall scores were more strongly associated with high affectionate support among men and with high

emotional/informational support among women. Pillemer et al.[94] also found that the cross-sectional association between emotional/informational support and global cognition was stronger for women than men in a sample of 355 community-dwelling older adults aged 65 years or older.

Education,[6,9,32,36,51,52,66,69,71,76,92,98,100,103,107,109,120-125] socio-economic status (e.g., wealth, social status), [74,75,92,98,103,110,128,129] health (e.g., co-morbidities, depressive symptoms, obesity),[6,9,53,57,74,75,87,92,94,98,102,107,110,120,128,129,131] lifestyle factors (e.g., smoking, drinking, physical activity, nutrition),[6,74,75,87,106,120] ethnicity,[131] and marital status[75,102,105,109] have also been examined as potential effect modifiers. However, few studies found actual evidence of moderation. Individuals with lower levels of education experienced stronger associations between high social support and better memory in two studies.[132,133] Ethnicity was also reported as a moderator by one study,[131] where the association between high emotional support and better working memory was negative for Hispanics and positive for Caucasians and African Americans.

1.5. Mechanisms Linking Social Support and Cognitive Function

Four theories/underlying mechanisms seek to explain the links between social support – both structural and functional – and cognitive function: stress-buffering hypothesis, cognitive reserve theory, social control and social identity theory, and use-it-or-lose-it theory. While the stress-buffering hypothesis most directly pertains to FSS (as opposed to structural social support) and cognitive function, all of the theories taken together are necessary to understand the complex nature of the association between social support and cognitive function.

1.5.1. Stress-Buffering Hypothesis

The stress-buffering hypothesis[85] primarily draws on stress physiology and advances the notion that stressors trigger adverse physiological reactions, such as stimulating the

hypothalamic-pituitary-adrenal (HPA) axis and elevating cortisol levels.[18,134] Cortisol plays a critical role in regulating cognitive function; chronically elevated cortisol has been shown to be associated with cognitive impairment.[114,135,136] In addition, stressors are also known to induce structural changes in the hippocampus,[54] which is one of the key brain regions involved in cognitive function, particularly memory.[19,23,31,111]

Aβ peptide and BDNF are thought to be potential pathways between social support and cognitive function, especially memory deficits.[32] Aβ peptide, derived from a membrane protein called amyloid precursor protein (APP), is produced from stressors and triggers a cascade of reactions in the brain, such as p35 conversion and removal of AMPA receptors from the synaptic membrane, which results in reduced synaptic plasticity and memory deficit.[32] Hsiao et al. propose that Aβ peptide may impair synaptic plasticity by inducing endocytosis of synaptic NMDA receptors and AMPA receptors, undermining dendritic spines and the cytoskeletal network, and disrupting neuronal glutamate uptake in the affected brain regions.[32]

BDNF protein, on the other hand, is a beneficial factor for cognitive function, particularly learning and memory.[32,37] Levels of BDNF fluctuate in response to social interactions, as shown by numerous studies on patients with depressive disorders, AD, and mild neurocognitive disorder.[32] Over-expression of BDNF through re-socialization and reinforcement of social connections has been shown to reduce the risk of cognitive impairment and delay the onset of AD.[32]

Under the stress-buffering hypothesis, social support may serve as a cushion against stressors and adverse life events, offsetting or ameliorating negative physiological reactions and protecting cognitive health.[57,81,98] Cohen et al.[85] propose that individuals may appraise a potentially stressful situation as not being all that serious if they know helpful resources are

available, or if they are guided by others to redefine the problem as solvable or acceptable. Receiving useful advice or encouragement to live healthy and positive lifestyles is an example of the types of social support that can help to buffer stress.[4,81] The absence of social interactions and the resulting psychosocial stress have also been associated with the onset of various neuropsychological disorders.[32]

A caveat is that the stress-buffering effect occurs only when specific stressors are directly matched by the type of social support an individual perceives as adequate to address a particular source of stress.[85] This suggests different types of social support, i.e., emotional, tangible, affectionate, and positive social interactions, may serve unique functions at different life stages or for different life events.[57,74] For example, emotional support (e.g., feelings of acceptance and self-worth) may help reduce feelings of helplessness, informational support (e.g., advice) may help reappraise stressful situations and develop coping strategies, tangible support may help by directly providing needed resources, and meaningful social interactions may help distract individuals from worry and facilitate positive moods.[85]

1.5.2. Cognitive Reserve Theory

Cognitive reserve refers to the ability of the human brain to actively mobilize existing (or create new) cognitive processing approaches to counter pathologic changes that may result in brain damage.[113] Cognitive reserve is the brain's coping mechanism against various physiological and psychological stressors in life;[9] it is different from "brain reserve," which is limited to the brain's physiological capacity to tolerate pathologic changes.[113]

Levels of cognitive reserve, not brain size, shape cognitive reserve. As such, pathological damage will have differential effects on individuals according to their cognitive reserve levels, while holding brain size constant.[113] According to observational and experimental studies,

cognitive reserve is accumulated or depleted across the lifetime through a combination of experiences, particularly education, occupational attainment, leisure activities in later life,[9,113] and other social and cognitively stimulating activities (e.g., learning new languages, having an occupation that requires mental calculations).[9] These activities increase cognitive reserve by enhancing neural connectivity and strengthening cognitive ability, all of which actively compensate for brain damage.[9]

Both structural and functional social support are important contributors to building cognitive reserve.[9] Interactions with family and friends in social and recreational settings involve complex communications, recollection of shared experiences, and shared problem-solving,[74] all of which provide psychological and cognitive stimulation,[137,138] thereby building up cognitive reserve. Being socially isolated deprives one of this stimulation and does not contribute to building cognitive reserve.[9] Many studies suggest cognitive reserve can be strengthened by frequent social activities and social integration,[9,139,140] but discussion of this point has been mostly limited to structural social support. However, one American study of 272 stroke patients aged 45 years or older found that higher emotional support was associated with stronger cognitive resilience.[141]

1.5.3. Social Control and Social Identity Theory

Social control and social identity theory[142,143] focuses on two mechanisms that motivate behaviour: (1) the direct effect of being prompted or persuaded by social ties (e.g., families, friends) to engage in healthier lifestyles and (2) the indirect effect of avoiding health risks on account of an obligation to one's significant others (e.g., parents avoiding unhealthy behaviours to keep their children from becoming orphans).[142]

Structural and functional social support provide important contexts for such direct and indirect effects on overall health, including cognitive health. A low level of FSS has been reported to be associated with unhealthy behaviours such as smoking, physical inactivity, and alcohol consumption,[84] while a high level of structural social support promotes exercise and healthy eating.[74,77] As discussed earlier, these lifestyle (e.g., alcohol and tobacco use,[54–56] fatty diet and obesity[56]) and psychosocial factors (e.g., stress[57]) influence cognitive functioning. Higher levels of activity are also believed to induce biochemical changes in brain regions that are critical for learning and memory.[32]

Moreover, a high level of FSS may also increase intellectual stimulation[144] and trigger psychological processes that enhance senses of control and positive emotions,[77] e.g., self-efficacy.[98] Indeed, research finds that informal and intimate relationships provide more sense of meaning and purpose as well as obligations than formal social ties,[143] which positively affects lifestyle and motivation. Marital status and parenthood, for example, are positively associated with healthier behaviors[142,143] and cognitive health.[129,144,145] A population-based, prospective cohort study in Finland[144] reported that, compared to married or cohabitating people, individuals living without a partner at mid-life had approximately twice the risk of developing cognitive impairment in later life and those living without a partner at mid-life and later life had three times the risk.

1.5.4. Use-It-Or-Lose-It Theory

The use-it-or-lose-it theory suggests that disuse of cognitive processes or skills will result in brain atrophy,[94,146] whereby inactive synaptic connections in the brain become weak over time and are eventually lost.[55] Cognitively stimulating activities that arise out of substantive social

interactions, including recall, attention, reasoning, and problem-solving[6] have been found to delay major cognitive disorders.[74]

Cross-sectional[127] and longitudinal studies[9,52,94,98,113,127,141,142] have reported associations between greater participation in physical, social, and intellectual activities on the one hand, and higher cognitive performance on a wide range of cognitive tasks on the other hand. In these studies, individuals with higher cognitive skills had more cognitively- and socially-engaged lifestyles, which in turn resulted in less cognitive decline than individuals with lower cognitive engagement.

1.5.5. Reverse Causality in the Association between Social Support and Cognitive Function

While much of the existing literature views social support as a protective factor against cognitive decline, another view suggests cognitive function largely determines the extent and the level of social support. In fact, some reports indicate individuals with cognitive decline may have difficulty communicating with others and, as a result, socially disengage with others[141] or receive less social support.[148] Individuals with lower cognitive function may also develop apathy[149–151] or depression,[152–154] or show greater increases in negative interactions with their families and friends.[104] Some authors suggest that impoverished social interactions are an early sign of psycho-behavioural dysfunction related to cognitive loss, and may be falsely interpreted as a risk factor for cognitive decline.[155,156] Meanwhile, the association between perceived social support and cognition may be a result of problem-solving or coping skills[89,120] that are promoted by good cognitive function. Those with better cognitive problem-solving skills are more likely to positively view their social support systems and benefit from these systems.

This view is contrasted by other studies. In one study,[107] the authors conducted a latent growth mediation analysis and concluded that cognitive function did not influence emotional and

tangible support. In two other studies,[147,157] the authors found that episodic memory did not predict social engagement and cognitive performance did not predict the extent of social activities.

Overall, evidence for reverse causality is equivocal. The link between social support and cognitive function may be bi-directional, with different effects dependent on the type of social support and cognitive domain under study. Factors such as age and sex may also affect the direction of association. Longitudinal studies are needed to examine the relation between social support and cognitive function.

1.6. Conclusion

Overall, a majority of the studies in the literature review showed positive associations between social support and cognitive function in older adults. Stronger FSS was associated with higher levels of cognitive function, including memory. Researchers have advanced multiple theoretical mechanisms to explain the association, including the stress-buffering hypothesis, which specifically pertains to FSS and its protective effect on memory. Evidence exists to suggest that age and sex may moderate the association between FSS and memory, although few studies tested for effect modification.

Some studies reported inverse associations between FSS and cognitive function. These findings may partially be attributed to the complex and bi-directional linkages between social support and cognition, or to variations in definitions and measurement of these constructs. Differences in study design and duration, age range of the study samples, and recruitment methods may also have contributed to the multiplicity of findings in the literature. For example, the relevant literature included 23 cross-sectional studies and 26 longitudinal studies with follow-up periods ranging from three to fifteen years. Characteristics of the participants also varied:

while most studies focused on older individuals aged 65 years or older, some included young and middle-aged adults. Most participants were cognitively intact individuals at baseline yet some had a family history of Alzheimer's disease.

The major obstacle to summarizing the published literature is heterogeneity in the definition and measurement of social support. Many studies fell short of distinguishing structural versus functional social support and often combined the two constructs into one measurement scale, which made it difficult to separate the impact of these rather distinct concepts on cognitive function. The scales used to measure FSS were diverse as well, and this fact detracted from the ability to compare findings across different studies of the same construct. As well, most of the relevant studies retrieved were limited in scope: among the 48 studies included in the literature review (excluding 3 reviews), 30 studies contained individuals aged 60 years or older, which reduced variability in the age range and thus limited the thesis candidate's ability to examine effect modification by age. Thirty-three studies recruited participants from limited geographical entities such as single cities or provinces, which could lead to selection biases based on specific characteristics of the geographies studied (e.g., urban centres, rural areas, retirement towns).

2.0. Study Rationale and Research Questions

2.1. Study Rationale

This thesis sought to address some of the gaps in the literature discussed above using baseline and three-year follow-up data in the Canadian Longitudinal Study on Aging (CLSA) by using validated tools to measure FSS and memory. The CLSA is a nation-wide, population-based study of over 30,000 middle-aged and older adults; it provided an excellent platform to investigate the association of interest in a large sample, with reduced likelihood of underpowered analyses or limitations due to age or geographically-restricted sample frames. Further, the CLSA contained a wealth of covariates to minimize residual confounding. Further, this thesis builds on previous cross-sectional studies involving CLSA data, both of which reported a positive association between higher levels of FSS and memory.[75,96]

2.2. Research Questions

(1) IS baseline level of FSS (overall and subtypes) associated with changes in memory over three years of follow-up in community-dwelling men and women aged between 45 and 85 years?

(2) Are the associations between FSS and memory maintained after controlling for sociodemographic, health, and lifestyle variables?

(3) Are the associations modified by age and sex?

3.0. Methods

3.1. Data Source: The Canadian Longitudinal Study on Aging

3.1.1. Background

The CLSA is a research platform designed to study the influence of biological, physical, psychological, social, and environmental factors on healthy aging.[158] The study takes a comprehensive, lifespan perspective toward aging and wellness to capture trajectories of physical, psychological, and psychosocial health.[158] The study also aims to identify potential risk and protective factors for health and social functioning in the context of major life transitions for persons aged 45 years or older.[158]

3.1.2. Study Design

The CLSA is a national, population-based, longitudinal study following 51,338 Canadians who were aged between 45 and 85 years at baseline.[159] The study consists of the Tracking and Comprehensive Cohorts. The Tracking Cohort includes 21,241 baseline participants recruited from all 10 provinces and followed up by telephone interview. The Comprehensive Cohort contains 30,097 baseline participants recruited from within 25 to 50 kilometers of 11 Data Collection Sites (DCS) located in seven provinces. Participants in the Comprehensive Cohort provide the same information as those in the Tracking Cohort, plus additional clinical, physical, and cognition data that are obtained during in-home interviews and in-person site visits.[158,159] Both cohorts are being followed up every three years for at least 20 years.

Information being collected from both cohorts includes data on demographic, social, physical/clinical, psychological, economic, and health service use.[73,158] Additional data in the Comprehensive Cohort include clinical tests (e.g., bone scans, spirometry), physical performance

tests (e.g., timed-up-and-go, chair rise), and cognitive tests (e.g., Victoria Stroop) that must be performed in person. Baseline data collection began in 2012 and data collection for the first follow-up timepoint ended in 2018.[159] Therefore, this thesis was able to draw upon two timepoints of data for analysis.

3.1.3. Thesis Sampling Frame and Eligibility Criteria

Data for the thesis were drawn from the Comprehensive Cohort to make use of the larger CLSA sample size for longitudinal analyses. Also, comparisons between telephone data from the Tracking Cohort and in-person data from the Comprehensive Cohort are lacking. The thesis candidate focused on a single cohort to avoid potential challenges with data compatibility across cohorts.

Study participants were selected into the Comprehensive Cohort from three primary sources: (1) provincial health care registration databases, (2) random digit dialing (RDD) of landline telephones, and (3) the Québec Longitudinal Study on Nutrition and Aging (NuAge).[160] Provincial health registration databases contained the contact information for most provincial residents who were eligible to receive public health insurance. Provincial ministries of health randomly selected eligible individuals from these databases, contacted them by mail, and sent them a packet of information about the CLSA. Recipients were told to contact the CLSA if they were interested in learning more about the study or participating. For RDD, a national polling firm randomly sampled and dialed landline telephone numbers. When an RDD call was answered, the operator explained the study, assessed the person's interest and eligibility, and passed the contact information of interested persons to the CLSA for formal enrolment.[161] NuAge was a five-year study of nutrition and aging in 1,800 older adults.[160] NuAge investigators

contacted participants between the ages of 75 and 85 years, told them about the CLSA, and forwarded the contact details of interested individuals to the CLSA for enrolment.

Participants were recruited into strata defined by province of residence, age group (45-54, 55-64, 65-74, 75-85 years), and sex. A further stratum for education (low education versus not low education) was introduced in the later stages of recruitment after the CLSA investigators noticed a preponderance of highly-educated persons being recruited into the study. The CLSA's Methodology Working Group devised sampling weights to reflect each participant's selection probability into the study.[160,161]

The CLSA excluded individuals living in the three Canadian territories or on First Nations reserves or settlements, people living in most long-term care institutions (except independent-living seniors' residences), those who did not speak English or French, persons who demonstrated overt signs of cognitive impairment at first contact with a CLSA employee, and full-time members of the Canadian Armed Forces.[158]

Approximately 10% of the persons contacted via the three recruitment methods described above agreed to join the Comprehensive Cohort; the recruitment proportions were comparable across the provinces.[160] Fourteen percent of the baseline participants were sampled from the provincial databases and 86% from RDD and NuAge.[161] A summary of the provincial response proportions is provided in Appendix B. Baseline data were available for 30,097 Comprehensive participants. Over the course of the first three-year follow-up period, 967 participants (3.21%) formally withdrew from the study, 1,365 participants (4.54%) dropped-out, and 974 participants (3.24%) passed away. Therefore, 27,765 participants with baseline and follow-up data formed the full thesis sample.

Participants who withdrew or dropped out were generally older and had lower levels of education, lower income, and poorer self-rated health than those who remained in the study over the full three-year time period.[159] Participants who were not included in the follow-up dataset had lower mean scores on all five FSS scales at baseline, as well as lower mean scores on both the immediate and delayed recall tests.

3.1.4. Analytical Sample

The analytical sample (n = 12,011) was extracted from the full sample of 27,765 participants. Participants were excluded from the analytical sample if they did not provide data during in-person interviews or DCS visits, were missing memory scores at one or both time points, were missing the response to any question on the MOS-SSS, or were missing a response to any baseline covariate (see Section 3.2.3 for the list of covariates). The flowchart describing the derivation of the analytical sample from the full sample is described in Appendix C.

3.2. Measures

3.2.1. Measurement of Memory

Participants in the Comprehensive Cohort completed a battery of neuropsychological tests to assess the memory and executive function domains of cognitive function. The CLSA's Psychological Working Group chose these domains and the specific tests in the battery because they are suitable for tracking normative trajectories of aging and abnormal cognitive declines in longitudinal studies.[73] This thesis used the memory domain as the outcome of interest.

The RAVLT is the single measure of memory in the CLSA.[73] This test measures episodic declarative memory,[71,162] verbal learning,[71,162–164] immediate memory,[71,162,163] retention of information,[162] post-inference recall[163] and visual recognition;[163] it is widely used to measure memory in clinical and research settings.[165,166] The RAVLT was selected for use in the CLSA

because it has good reliability ($0.51 \leq r \leq 0.86$)[73] and high sensitivity to detecting preclinical Alzheimer's disease,[73,166–168] and is available in English and French.[73] The CLSA adopted only Trial I from Trials I through V of the full RAVLT instrument. Further, the CLSA did not utilize the RAVLT's interference test.[73]

The RAVLT was administered twice during DCS visits to obtain measures of immediate memory recall (RAVLT I) and delayed memory recall (RAVLT II). For RAVLT I, participants listened to a list of 15 recorded words (see Appendix D) and were immediately asked to recall as many of the words as possible, in any order, within 90 seconds. RAVLT II was administered five minutes later and participants were asked to recall as many of the same words as possible, without hearing the list again, within 60 seconds.[169] The RAVLT was administered and scored using the same protocol at baseline and follow-up.

RAVLT I and II each measure different components of memory. RAVLT I measures short-term memory and reflects the phonological loop from working memory,[170] whereas RAVLT II measures complex memory functions such as skill in initial encoding, consolidation, and retrieval of information.[71,162] These differences make the delayed recall test more demanding than the immediate recall test.

All responses were recorded electronically and independently entered into a database by two staffers. Conflicting entries were identified and resolved by a supervisor. Each word correctly recalled was awarded one point and each acceptable variant word was also awarded one point. Variant words were drawn from a list of permitted words that sounded similar to the 'primary' words on the recording (i.e., "collar" for "colour"). For words other than primary or variant words, zero points were awarded. If a participant recalled a variant word in RAVLT I, then s/he had to recall the same variant word to earn a point in RAVLT II.[171] Staff assigned

missing values to participants who did not provide permission to record responses, as well as to participants whose recordings were garbled or blank.

This thesis utilized test data from the baseline and the three-year follow-up timepoints. Raw test scores for each administration were transformed into z-scores with $\mu = 0$ and $\sigma = 1$, with the z-scores calculated separately for English and French speakers. Participants who switched languages during either RAVLT I or RAVLT II were excluded from the analysis (n = 4 at baseline, n = 12 at follow-up).

3.2.1.1. Combined Memory Score

Although RAVLT I and II measure different components of memory, the RAVLT I and II z-scores had comparable distributions to one another at each time point. Also, RAVLT I and II change scores were comparable to one another in terms of means, and roughly comparable to one another in terms of distributions. Please refer to Section 4.1.3 of the Results for descriptive data and graphs. For these reasons, the thesis candidate elected to combine RAVLT I and II into a single measure of memory. To obtain this measure, the baseline RAVLT I and II z-scores were added together and averaged to obtain a single baseline memory score for each participant. The process was repeated for the RAVLT I and II follow-up z-scores. Change scores were computed by subtracting the averaged RAVLT I/II z-score at baseline from the averaged RAVLT I/II z-score at follow-up.[172]

Further justification for combining RAVLT I and II z-scores emerged after finding that the literature was inconclusive regarding the differential impact of FSS on immediate versus delayed recall memory. A majority of the studies measuring both types of memory combined the test results into composite memory scores.[98,105,109,111,127,132] Only two articles[133,141] reported the memory tests separately, but neither paper applied directly to the thesis, as one measured

loneliness[133] instead of FSS and the other[141] measured combinations of structural and functional support in post-stroke individuals.

3.2.2. Measurement of Functional Social Support

FSS was measured with the Medical Outcomes Study Social Support Survey (MOS–SSS).[101] This survey is a 19-item, self-administered scale measuring overall FSS and four subtypes of FSS – emotional/informational (8 items), tangible (4 items), affectionate (3 items), and positive social interactions (3 items). The 19 items are shown in Appendix E. The MOS–SSS has high internal consistency (overall and subscale Cronbach's alphas range from 0.91 to 0.97)[94,173] and test-retest reliability (ICC = 0.78 after one year).[174] English and French versions of the MOS–SSS have been reported to function uniformly.[173]

Emotional/informational support measures positive affect, presence of empathetic understanding and encouragement, and availability of advice or guidance to cope with difficult situations or problems.[57,94] Tangible support measures the provision of material or behavioural assistance, help with chores, and provision of transportation.[57,94] Affectionate support measures expressions of love and affection. Positive social interaction measures whether one has access to others with whom to engage in pleasant social activities. For each question on the MOS–SSS, participants rated the level of support on the following scale: 1 (none of the time), 2 (a little of the time), 3 (some of the time), 4 (most of the time), or 5 (all of the time).[101]

The overall social support score was the average of the scores on all 19 questions; the score for each subtype was the average of the scores for the questions assigned to that subtype. This thesis used only baseline FSS scores; the distribution of these scores, including medians and quartiles, were comparable between baseline and follow-up (see Section 4.1.2).

3.2.3. Covariates

Twelve covariates were included in the analyses of the association between FSS and memory. This thesis used only baseline data from these covariates after ascertaining that changes in their distributions between the two time points were minimal (see Section 4.1.1). Guided by CLSA recommendations,[160] participants' sex, age group, and province of residence were included as independent variables in all of the regression models to account for the sample strata/complex survey design. The inclusion of 10 additional covariates beyond these three variables was based on the findings of previous studies (including systematic reviews) that investigated the association between FSS and cognitive function (see the literature review above and the studies listed in Appendix A below).

Among the chosen covariates, levels of education and chronic health conditions were used in 36 and 32 studies, respectively (Appendix A). Adjustment for education is particularly relevant for this thesis because levels of education have been shown to influence RAVLT scores.[165] Depressive symptoms, functional status, and household income were also controlled for in 23, 18, and 13 articles, respectively (Appendix A). The inclusion of marital status and living arrangements as covariates was informed by six studies[41,118,175–178]; and alcohol and tobacco use were included based on findings reported for three studies.[82–84]

The nine additional covariates were categorized into three groups: (1) sociodemographic (education, annual household income, marital status, and living arrangements), (2) health (chronic conditions, functional status [Basic Activities of Daily Living or ADL, Instrumental Activities of Daily Living or IADL], depressive symptoms), and (3) lifestyle (smoking status, alcohol use). A conceptual diagram of the linkage between covariates, exposure variable(s), and outcome variable(s) is provided in Appendix F.

3.2.3.1. Sociodemographic Variables

In CLSA, *sex* was measured dichotomously as male or female, and *age* was measured in years and divided into four groups: 45-54 years, 55-64 years, 65-74 years, and 75 years or older. *Education* was assessed with a four-level scale representing the highest degree obtained by participants: less than high school, high school diploma, some post-secondary education, and post-secondary degree/diploma. *Province of residence* was determined at recruitment. *Total annual household income* was assessed on a five-level scale: less than $20,000, from $20,000 to under $50,000, from $50,000 to under $100,000, from $100,000 to under $150,000, and $150,000 or more. *Marital status* was determined via a five-level scale: single, never married or lived with a partner, married or lived with a partner in a common-law relationship, widowed, divorced or separated. For the thesis, marital status was dichotomized with a score of 1 if participants were married or living with a partner in a common-law relationship, or 0 if any other response applied.[177] *Living arrangement* was assessed by counting the number of people with whom the participants lived. For the thesis, living arrangement was dichotomized as living alone (score = 0) if the number of cohabitants was none or living with someone (score = 1) if the number of cohabitants was ≥ 1.[177,179]

3.2.3.2. Health Variables

Chronic conditions were assessed through participants' self-reports of whether a doctor ever told them they had any of the following 11 chronic conditions that have been reported to be associated with cognitive function[96] (response: yes or no for each condition): high blood pressure (or hypertension), diabetes (or borderline diabetes or high blood sugar), cancer, hypothyroidism (or under-active thyroid gland or myxedema), chronic obstructive pulmonary disease (or emphysema or chronic bronchitis), kidney disease (or kidney failure), cardiac chronic conditions

(heart disease/ congestive heart failure, myocardial infarction/ acute myocardial infarction/ heart attack, angina/ chest pain due to heart disease), stroke-related conditions, peripheral vascular disease, and asthma. The thesis candidate totaled the number of chronic conditions for which the response was 'yes' and created a four-level ordinal variable, i.e., diagnosis with 0, 1, 2, or ≥ 3 chronic conditions.

Functional status was assessed using measures of ADL and IADL. These measures came from the Older Americans Resources and Services (OARS) Multidimensional Assessment Questionnaire.[180] ADL questions evaluate participants' ability to perform seven basic daily tasks such as eating, dressing, grooming, and walking; IADL assesses one's ability to perform seven high-level daily functions such as grocery shopping, money handling, meal preparation, and taking medications. For this thesis, ADLs and IADLs were operationalized using a derived variable in the CLSA dataset called 'Basic and Instrumental Activities of Daily Living Classification'. This variable combines the ADL and IADL responses into a five-point scale from 1 (no functional impairment) to 5 (total impairment).[181] The derived variable also assigns extra weight to an inability to prepare one's own meals, reflecting the OARS authors' recommendation that inability to prepare meals is more detrimental to independent living than other activities of daily living.[181] The OARS scale has been extensively validated and demonstrates high correlations with physical therapists' assessments of self-care capacity.[182] Due to the highly skewed distribution of the derived variable in the analytical sample, it was re-categorized into three groups: 1 (no functional impairment), 2 (mild impairment), and 3 (moderate, severe, and total impairment).

Depressive symptoms were measured via the Center for Epidemiologic Studies Short Depression Scale (CES-D10), which contains 10 questions about items such as feelings of

depression, loneliness, problems with concentration, and restless sleep. Participants were asked to indicate how often they experienced such feelings in the past seven days on a four-point scale: 0 (rarely or never), 1 (some of the time), 2 (occasionally), and 3 (all of the time). Total scores ranged from 0 to 30, with scores ≥ 10 indicating the presence of a severe constellation of depressive symptoms.[174] In this thesis, the continuous CES-D10 score was included in the regression models to avoid the loss of information that accompanies categorizing continuous variables.

3.2.3.3. Lifestyle Variables

Smoking status was measured by a 23-item self-assessment questionnaire adapted from the Canadian Health Measures Survey (CHMS)[183] and the Canadian Tobacco Use Monitoring Survey (CTUMS).[184] Based on responses to these questionnaires, participants were classified as current smokers, former smokers, or never smokers. Participants who answered that they smoked daily or occasionally at the present time were categorized as current smokers. Participants who answered that they smoked ≥ 100 cigarettes in their lives yet did not smoke at all or occasionally at the present time were categorized as former smokers. Participants who answered that they had never smoked ≥ 100 cigarettes in their lives were categorized as never smokers.

Alcohol use was measured by a 6-item questionnaire sourced from the Centre for Addiction and Mental Health Monitor,[185] which quantified the amount and type of alcohol participants reported consuming in the past 12 months. The thesis employed a derived variable ("Type of Drinker_12 Months") from the CLSA. The derived variable was created based on participants' responses to two questions: (1) whether they ever consumed alcohol and (2) how often they consumed it during the past 12 months.[186] Participants who reported consuming alcohol at least once a month were classified as regular users and less than once a month as

occasional users. Participants who “did not drink in the past 12 months” or who reported never drinking at all were classified as non-users of alcohol.

3.3. Data Analyses

3.3.1. Descriptive Analysis

Baseline descriptive statistics were computed for overall FSS and each of the four FSS subtypes, as well as for all 13 covariates. Baseline and follow-up z-scores were computed for RAVLT I and RAVLT II. Differences in the z-scores between baseline and follow-up (change scores, see Section 3.3.2.1) were also computed separately for RAVLT I, II, and composite RAVLT. Baseline and follow-up distributions were also computed for all FSS variables to assess distributional changes over time.

Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as means and standard deviations if normally distributed, and medians and interquartile ranges if non-normally distributed. Descriptive data were reported twice, once as unweighted, and secondly as weighted, to provide a complete description of participants’ characteristics at baseline. The CLSA’s trimmed weights and the geographical strata variable were used to obtain the weighted descriptive data.[160]

The differences in unweighted RAVLT I and II z-scores between baseline and follow-up were compared using the Wilcoxon signed-rank test. Scatterplots and Pearson correlation coefficients were utilized to descriptively examine links between FSS at baseline (unweighted) and changes in z-scores between baseline and follow-up (unweighted). These comparisons utilized the unweighted data due to computational limitations with the statistical software.

3.3.2. Regression Analysis

3.3.2.1. Change Score Analysis

The thesis regressed RAVLT change scores (follow-up combined score – baseline combined score) on the independent variables. Change score analysis is recommended for longitudinal studies with only two time points[172] and is widely used for longitudinal observations of neurodegenerative progression and cognitive decline.[187–190] By accounting for correlation/dependence between the two available sets of scores, change score analysis provides smaller variability and higher sensitivity[191,192] in comparison to retaining separate baseline and follow-up scores in regression models. Further, the commonly cited concern surrounding change score analysis, i.e., regression toward the mean,[191,193–196] was ruled out in the analytical sample used in this thesis, as the memory scores used to calculate the change scores exhibited fairly normal distributions without outliers.

3.3.2.2. Multiple Linear Regression

The RAVLT change scores were fairly normally distributed around zero, with roughly half of the participants showing positive changes and the other half exhibiting negative changes (see Section 4.1.3 below). Over half of the changes in either direction were small in magnitude (< 1 point). To avoid misclassification of the true change by using arbitrary cut-off points,[188,189] and in the absence of a reliable change index (RCI) for RAVLT, the change scores were treated continuously in the regression analyses.

The regression models included separate investigations of each of the five FSS variables (overall FSS and the four subscales) as main effects. FSS variables were dichotomized as low (score between 1 to 3)[197] or high (score of 4 or 5) to account for highly skewed distributions. Baseline combined RAVLT scores were included in the models as informed by the literature.[187]

For each regression, two models were built: a base model and a full model. The base model included the FSS variable of interest, baseline combined RAVLT score, age group, sex, and province of residence. Including age group, sex, and province of residence was recommended by the CLSA to account for the complex survey design.[160] The full model adjusted for nine more covariates: sociodemographic variables (education, annual household income, marital status, and living arrangement), health variables (functional status, number of chronic conditions, and depressive symptoms), and lifestyle variables (tobacco use and alcohol use).

Each full model was assessed for fit using residual and observed versus predicted plots. A random scatter of residuals (y-axis) across the predicted values (x-axis) was seen as evidence of acceptable model fit. Plots of observed RAVLT change scores (y-axis) against predicted RAVLT change scores (x-axis) produced evidence of acceptable model fit if the plot points created slopes closer to 1.0 or -1.0.

The full regression models were stratified separately by age group and sex. Descriptive and regression analyses of change scores were conducted for each age and sex stratum.

3.3.3. Missing Data

Complete case analysis was the method of handling missing data in the regression analysis. To assess the potential impact of missing data, bivariate analyses were performed to examine differences in the distribution of FSS scores among individuals with fully observed RAVLT values and individuals with missing RAVLT values. Likewise, the distribution of RAVLT scores was compared between participants with complete FSS scores and participants with missing FSS scores. The Mann-Whitney U test was used to assess the statistical significance of the comparisons.

3.4. Statistical Software

SAS v9.4 (The SAS Institute, Cary, NC) and the SURVEYREG, SURVEYMEANS, SURVEYFREQ, MEANS, FREQ, and NPAR1WAY procedures were used for all statistical analyses. The SURVEY procedures account for the analytical weight and geographical strata variables used in the CLSA. R v4.0.2[198] (The R Project for Statistical Computing, Vienna, Austria) and the 'ggplot2' and 'ggpubr' packages were used to produce graphs.

3.5. Ethics

The CLSA received ethics approval from all of the institutions hosting Data Collection Sites. Detailed descriptions of ethical considerations, ongoing ethics review, and integrity of data protection are available elsewhere.[174] This thesis falls under the rubric of a research project entitled "Profiles of Socially and Cognitively Vulnerable Canadians: A Cross-sectional Analysis of the Canadian Longitudinal Study on Aging (CLSA)", which received approval from the University of Waterloo's Office of Research Ethics (ORE # 30793). The thesis candidate received the CLSA's approval to access the data for her thesis in January 2020 and was added to the University of Waterloo's ethics certification as a student investigator.

4.0. Results

4.1. Participant Characteristics

4.1.1. Distribution of Sociodemographic, Health, and Lifestyle Variables

The analytical samples for combined RAVLT change scores contained 12,011 (unweighted) and 1,649,718 (weighted) participants, respectively. The process used to extract the analytical samples is depicted in Appendix C.

Weighted sociodemographic, health, and lifestyle characteristics for the analytical sample are presented in Table 4.1. Weighted descriptive statistics for the analytical sample showed that 77% of the participants were under the age of 65 years; 81.7% of the participants had at least some post-secondary education; and approximately 60% of the participants were living in British Columbia and Québec, followed by approximately 25% living in Alberta and Ontario. Almost 80% of the participants were married or living with a partner and approximately 13% lived alone. In terms of annual household income, almost half of the participants reported incomes of $1,000,000 or higher.

Over 70% of the analytical sample (weighted) reported one or less chronic conditions and 95% had no functional impairment. Seventy-five percent of the participants scored below 6.78 on the CES-D-10. Over 90% of the participants were never or former smokers and over 80% of the participants were regular drinkers. The descriptive characteristics for the full baseline unweighted sample (n = 30,097) were similar to the characteristics for the unweighted analytical sample (Appendix H).

Table 4.1. Sociodemographic, Health, and Lifestyle Characteristics of the Analytical Sample

Characteristics	Unweighted n = 12,011 n (%)	Weighted n = 1,649,717 n (%)
Sex		
Male	5,930 (49.37)	827,099 (50.14)
Female	6,081 (50.63)	822,619 (49.86)
Age Group		
45-54 years	3,603 (30.00)	776,340 (47.06)
55-64 years	4,284 (35.67)	502,440 (30.46)
65-74 years	2,842 (23.66)	263,417 (15.97)
75 years and older	1,282 (10.67)	107,521 (6.52)
Province		
Alberta	1,222 (10.17)	207,780 (12.59)
British Columbia	2,685 (22.35)	513,750 (31.14)
Manitoba	1,074 (8.94)	112,243 (6.80)
Newfoundland & Labrador	878 (7.31)	34,098 (2.07)
Nova Scotia	829 (6.90)	38,827 (2.35)
Ontario	2,747 (22.87)	223,392 (13.54)
Quebec	2,576 (21.45)	519,628 (31.50)
Education		
Less than high school	483 (4.02)	58,907 (3.57)
High school diploma	1,067 (8.88)	140,202 (8.50)
Some post-secondary	834 (6.94)	102,374 (6.21)
Post-secondary diploma	9,627 (80.15)	1,348,234 (81.73)
Annual Household Income		
≤ $19,999	473 (3.94)	53,159 (3.22)
$ 20,000 – 49,999	2,253 (18.76)	258,405 (15.66)
$ 50,000 – 99,999	4,233 (35.24)	535,478 (32.46)
$ 100,000 – 149,999	2,606 (21.70)	402,769 (24.41)
≥ $ 150,000	2,446 (20.36)	399,906 (24.24)
Marital Status		
Married or common-law	8,778 (73.08)	1,311,361 (79.49)
Single, widowed, divorced, separated	3,233 (26.92)	338,356 (20.51)
Living Arrangement		
Alone	2,289 (19.06)	215,359 (13.05)
With others	9,722 (80.94)	1,434,359 (86.95)
Chronic Conditions		
None	4,291 (35.73)	669,170 (40.56)
1	3,874 (32.25)	533,224 (32.32)
2	2,246 (18.70)	271,913 (16.48)
3 or more	1,600 (13.32)	175,410 (10.63)

Table 4.1. (Cont'd) Sociodemographic, Health, and Lifestyle Characteristics of the Analytical Sample

Characteristics	Unweighted n = 12,011 n (%)	Weighted n = 1,649,718 n (%)
Functional Status		
No functional impairment	11,299 (94.07)	1,568,472 (95.08)
Mild impairment	666 (5.54)	75,640 (4.59)
Moderate, severe, total impairment	46 (0.38)	5,605 (0.34)
Depressive Symptoms*	4.00 (5.00)	3.52 (5.47)
Smoking Status		
Never smoker	5,811 (48.38)	843,002 (51.10)
Former smoker	5,308 (44.19)	679,964 (41.22)
Current smoker	892 (7.43)	126,752 (7.68)
Alcohol Use		
No drinker	1,218 (10.14)	161,609 (9.80)
Occasional drinker	1,290 (10.74)	162,233 (9.83)
Regular drinker	9,503 (79.12)	1,325,876 (80.37)

* Median (inter-quartile range)

The sociodemographic, health, and lifestyle characteristics remained largely stable over three years (Table 4.2). Six percent of the participants in the analytical sample underwent changes in marital status from married/common-law partnership to single, widowed, separated, or divorced. The percentage of individuals with three or more chronic conditions increased by three percent. Two percent of the participants reported development of mild functional impairment.

Table 4.2. Distribution of Participant Characteristics at Baseline and Follow-up (Weighted)

Characteristics	Baseline n = 1,649,717 n (%)	Follow-up n = 1,649,717 n (%)
Annual Household Income		
≤ $19,999	53,159 (3.22)	46,018 (2.88)
$ 20,000 – 49,999	258,405 (15.66)	248,680 (15.56)
$ 50,000 – 99,999	535,478 (32.46)	541,425 (33.89)
$ 100,000 – 149,999	402,769 (24.41)	365,950 (22.90)
≥ $ 150,000	399,906 (24.24)	395,712 (24.77)
Marital Status		
Married or common-law	1,311,361 (79.49)	1,205,142 (73.05)
Single, widowed, divorced, separated	338,356 (20.51)	444,576 (26.95)
Living Arrangement		
Alone	215,359 (13.05)	252,209 (15.29)
With others	1,434,359 (86.95)	1,397,508 (84.71)
Chronic Conditions		
None	669,170 (40.56)	582,470 (36.07)
1	533,224 (32.32)	518,121 (32.09)
2	271,913 (16.48)	295,501 (18.30)
3 or more	175,410 (10.63)	218,730 (13.55)
Functional Status		
No functional impairment	1,568,472 (95.08)	1,474,075 (92.89)
Mild impairment	75,640 (4.59)	106,915 (6.74)
Moderate, severe, total impairment	5,605 (0.34)	5,917 (0.37)
Depressive Symptoms*	3.52 (5.47)	3.36 (5.50)
Smoking Status		
Never smoker	843,002 (51.10)	843,002 (51.11)
Former smoker	679,964 (41.22)	695,041 (42.14)
Current smoker	126,752 (7.68)	111,330 (6.75)
Alcohol Use		
No drinker	161,609 (9.80)	139,672 (8.47)
Occasional drinker	162,233 (9.83)	169,550 (10.28)
Regular drinker	1,325,876 (80.37)	1,340,113 (81.25)

* Median (inter-quartile range)

4.1.2. Distribution of Functional Social Support

Participants' weighted FSS scores were left-skewed (Figure 4.1). The weighted median scores for FSS (overall and subtypes) at baseline ranged from 4.33 to 4.70 (Table 4.3). The median for overall FSS was 4.46 and affectionate support the highest median of 4.70. Seventy-five percent of the participants scored 4.80 or higher in each FSS subtype, including overall FSS. When categorized into high (4-5) and low (1-3) scores, 92 to 95% of the participants in the analytical sample reported high FSS (Table 4.4).

Figure 4.1. Distribution of Weighted FSS Scores (Overall and Subtypes)

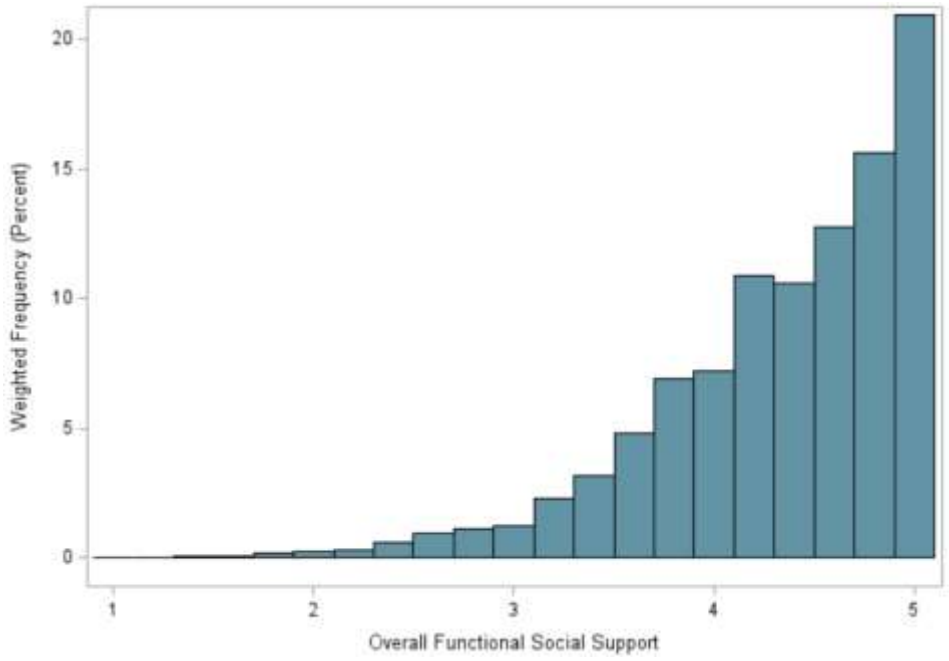
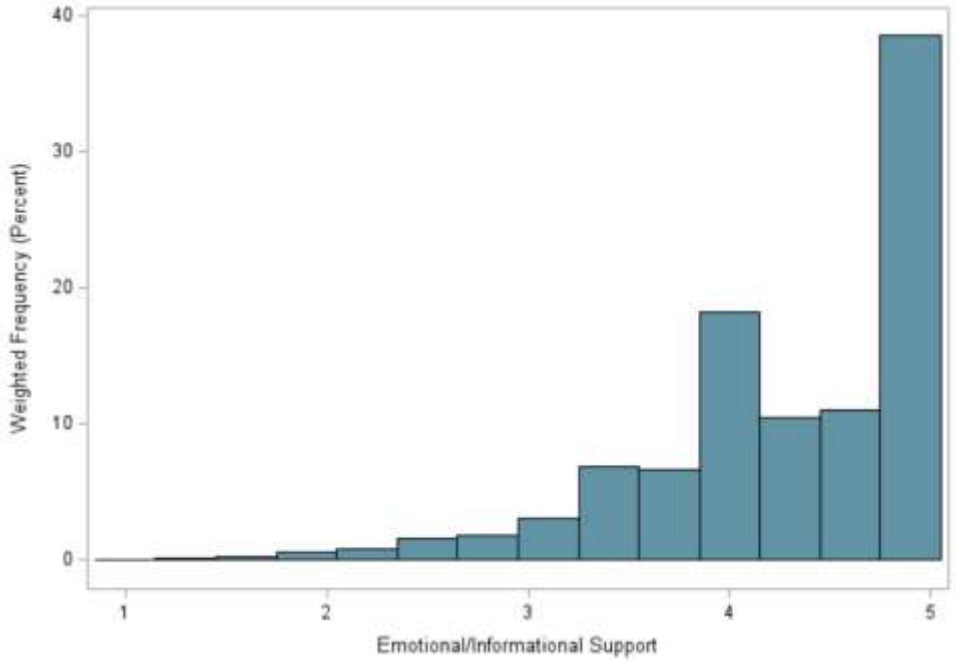


Figure 4.1. (Cont'd) Distribution of Weighted FSS Scores (Overall and Subtypes)



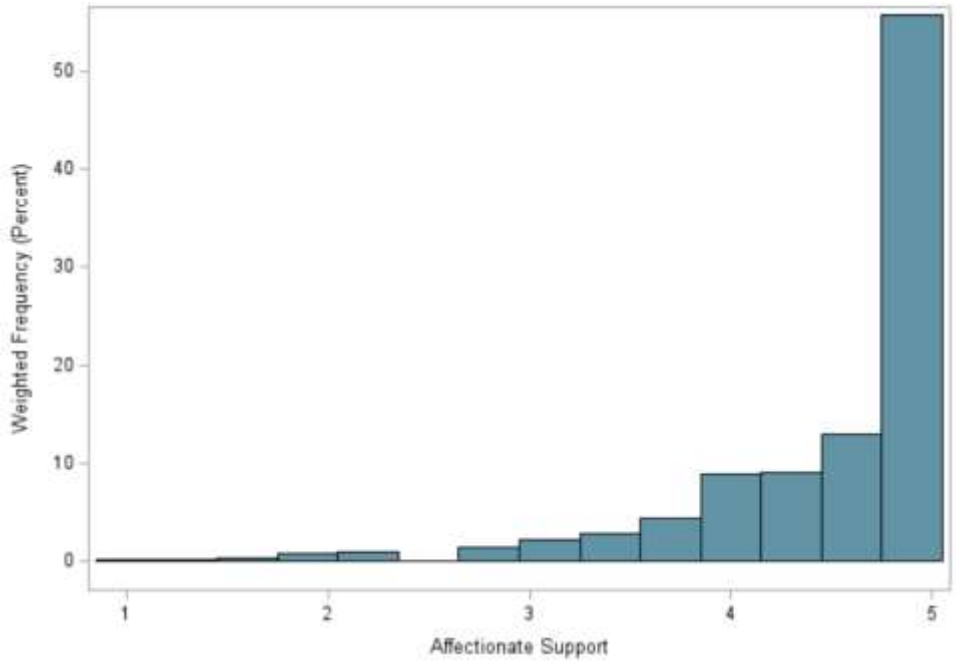
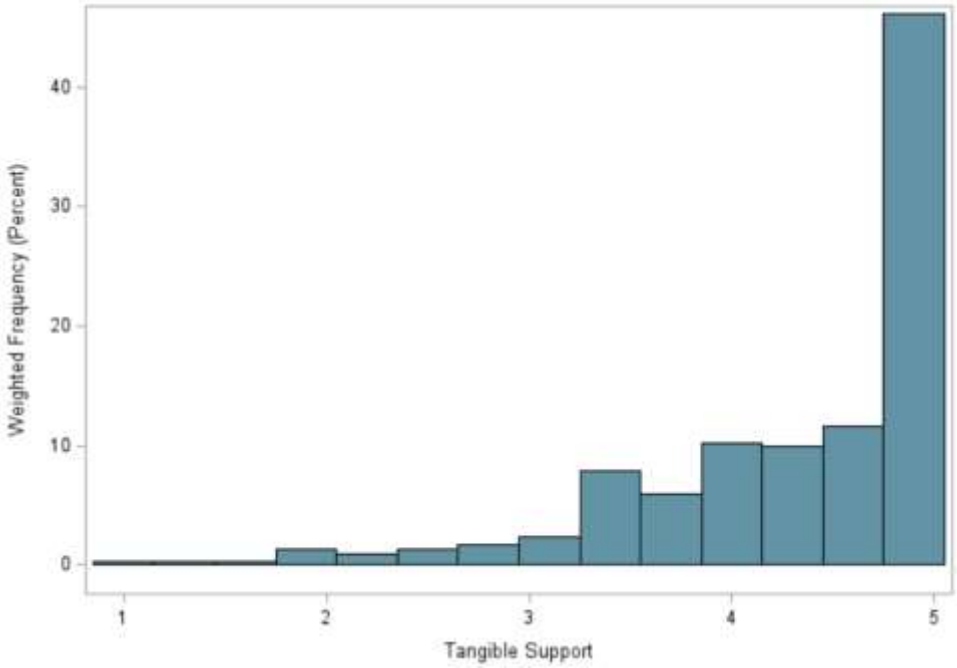


Figure 4.1. (Cont'd) Distribution of Weighted FSS Scores (Overall and Subtypes)



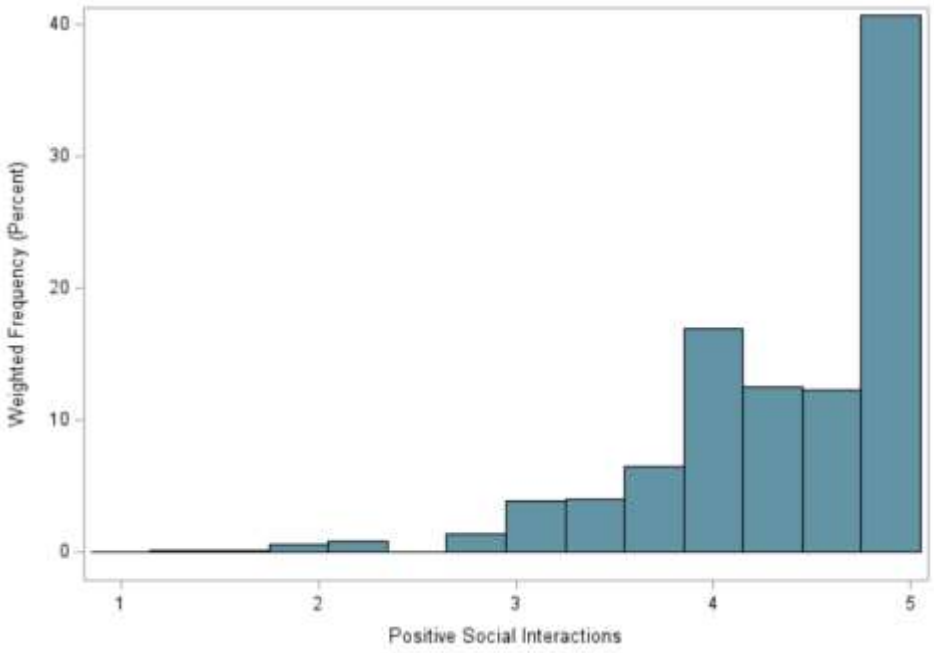


Table 4.3. Distribution of FSS Scores, Continuous

FSS	Unweighted n = 12,011	Weighted n = 1,649,718
	Median (IQR)	Median (IQR)
Overall FSS	4.47 (0.89)	4.46 (0.88)
EMI	4.38 (1.00)	4.37 (1.03)
AFF	5.00 (0.67)	4.70 (0.75)
TAN	4.50 (1.00)	4.42 (0.99)
POS	4.67 (0.89)	4.41 (0.98)

FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support
TAN: Tangible Support; POS: Positive Social Interactions; IQR: inter-quartile range

Table 4.4. Distribution of FSS Scores, Dichotomized

FSS		Unweighted (n = 12,011)	Weighted (n = 1,649,718)
Overall FSS	Low*	645 (5.37)	72,631 (4.40)
	High**	11,366 (94.63)	1,577,087 (95.60)
EMI	Low	906 (7.54)	108,932 (6.60)
	High	11,105 (92.46)	1,540,785 (93.40)
AFF	Low	885 (7.37)	100,307 (6.08)
	High	11,126 (92.63)	1,549,411 (93.92)
TAN	Low	1,200 (9.99)	135,617 (8.22)
	High	10,811 (90.01)	1,514,100 (91.78)
POS	Low	991 (8.25)	116,473 (7.06)
	High	11,020 (91.75)	1,531,364 (92.94)

* scores 1-3, ** scores 4-5
FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support
TAN: Tangible Support; POS: Positive Social Interactions

The weighted FSS scores generally showed comparable distributions across the four age groups (Table 4.5) and sexes (Table 4.6). While the proportion of participants with high weighted FSS was slightly lower in the oldest age group (≥ 75 years) compared to the other age groups, and in males compared to females, individuals in all age and sex strata reported a predominantly high level of FSS.

Table 4.5. Distribution of FSS Scores by Age Group (Weighted)

FSS		45-64 years (n = 776,340)	55-64 years (n = 502,439)	65-74 years (n = 263,418)	≥ 75 years (n = 107,522)
Overall FSS	Low*	28,489 (3.67)	24,854 (4.95)	11,604 (4.41)	7,684 (7.15)
	High**	747,851 (96.33)	477,586 (95.05)	251,814 (95.60)	99,837 (92.85)
EMI	Low	42,138 (5.43)	34,983 (6.96)	19,314 (7.33)	12,497 (11.62)
	High	734,202 (94.57)	467,457 (93.04)	244,103 (92.67)	95,024 (88.38)
AFF	Low	40,281 (5.19)	35,509 (7.07)	15,879 (6.03)	8,638 (8.03)
	High	736,059 (94.81)	466,931 (92.93)	247,538 (93.97)	98,883 (91.97)
TAN	Low	56,676 (7.30)	43,907 (8.74)	22,426 (8.51)	12,608 (11.73)
	High	719,663 (92.70)	458,533 (91.26)	240,991 (91.49)	94,913 (88.27)
POS	Low	50,410 (6.49)	39,567 (7.88)	16,577 (6.29)	9,883 (9.19)
	High	725,930 (93.51)	462,873 (92.13)	246,840 (93.71)	97,638 (90.81)

* scores 1-3, ** scores 4-5
FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support
TAN: Tangible Support; POS: Positive Social Interactions

Table 4.6. Distribution of FSS Scores by Sex (Weighted)

FSS		Male (n = 827,099)	Female (n = 822,619)
Overall FSS	Low*	40,343 (4.88)	32,288 (3.93)
	High**	786,756 (95.12)	790,331 (96.08)
EMI	Low	64,903 (7.85)	44,029 (5.35)
	High	762,196 (92.15)	778,590 (94.65)
AFF	Low	55,145 (6.67)	45,161 (5.49)
	High	771,953 (93.33)	777,458 (94.51)
TAN	Low	57,414 (6.94)	78,203 (9.51)
	High	769,685 (93.06)	744,415 (90.49)
POS	Low	62,870 (7.60)	55,483 (6.74)
	High	764,229 (92.40)	767,135 (93.26)

* scores 1-3, ** scores 4-5
FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support
TAN: Tangible Support; POS: Positive Social Interactions

FSS scores did not change substantially over three years. Distributions of overall and subtypes of FSS at follow-up were left-skewed, similar to the distributions at baseline (Table 4.7).

Table 4.7. Distribution of FSS Scores at Baseline and Follow-up (Weighted)

FSS	Baseline n = 1,649,718	Follow-up n = 1,649,718
	Median (IQR)	Median (IQR)
Overall FSS	4.46 (0.88)	4.42 (0.95)
EMI	4.37 (1.03)	4.30 (1.05)
AFF	4.70 (0.75)	4.67 (0.89)
TAN	4.42 (0.99)	4.43 (1.02)
POS	4.41 (0.98)	4.32 (1.03)

4.1.3. Distribution of Memory Scores

Weighted baseline and follow-up z-scores for RAVLT I were similarly distributed and comparable to one another, with a slight decrease in the mean at the follow-up; the same was observed for RAVLT II z-scores (Table 4.8 and Figure 4.2). Weighted means after combining RAVLT I/II z-scores were fairly normally distributed at both time points (Table 4.8 and Figure 4.3). Mean combined and weighted RAVLT z-scores were 0.24 (95% confidence interval [CI]: 0.22, 0.26) at baseline and -0.01 (95% CI: -0.03, 0.01) at follow-up, showing a slight decrease over three years.

Table 4.8. Distribution of Weighted RAVLT I, II and Combined RAVLT I/II Z-Scores at Baseline and Follow-up

		Mean (SEM) (95% CI)	Median (IQR)	Minimum	Maximum
RAVLT I	Baseline	0.23 (0.01) (0.21, 0.25)	0.01 (1.32)	-3.11	4.22
	Follow-up	-0.00 (0.01) (-0.02, 0.02)	-0.13 (1.33)	-2.98	3.75
RAVLT II	Baseline	0.24 (0.01) (0.22, 0.26)	0.03 (1.24)	-1.95	4.53
	Follow-up	-0.01 (0.01) (-0.04, 0.01)	-0.18 (1.31)	-1.96	4.23
Combined RAVLT	Baseline	0.24 (0.01) (0.22, 0.26)	0.22 (1.26)	-2.48	4.14
	Follow-up	-0.01 (0.01) (-0.03, 0.01)	-0.08 (1.21)	-2.47	3.99

RAVLT: Rey Auditory Verbal Learning Test, CI: confidence interval; IQR: inter-quartile range
SEM: Standard Error of Mean

Figure 4.2. Distribution of RAVLT I & II Z-Scores at Baseline and Follow-up

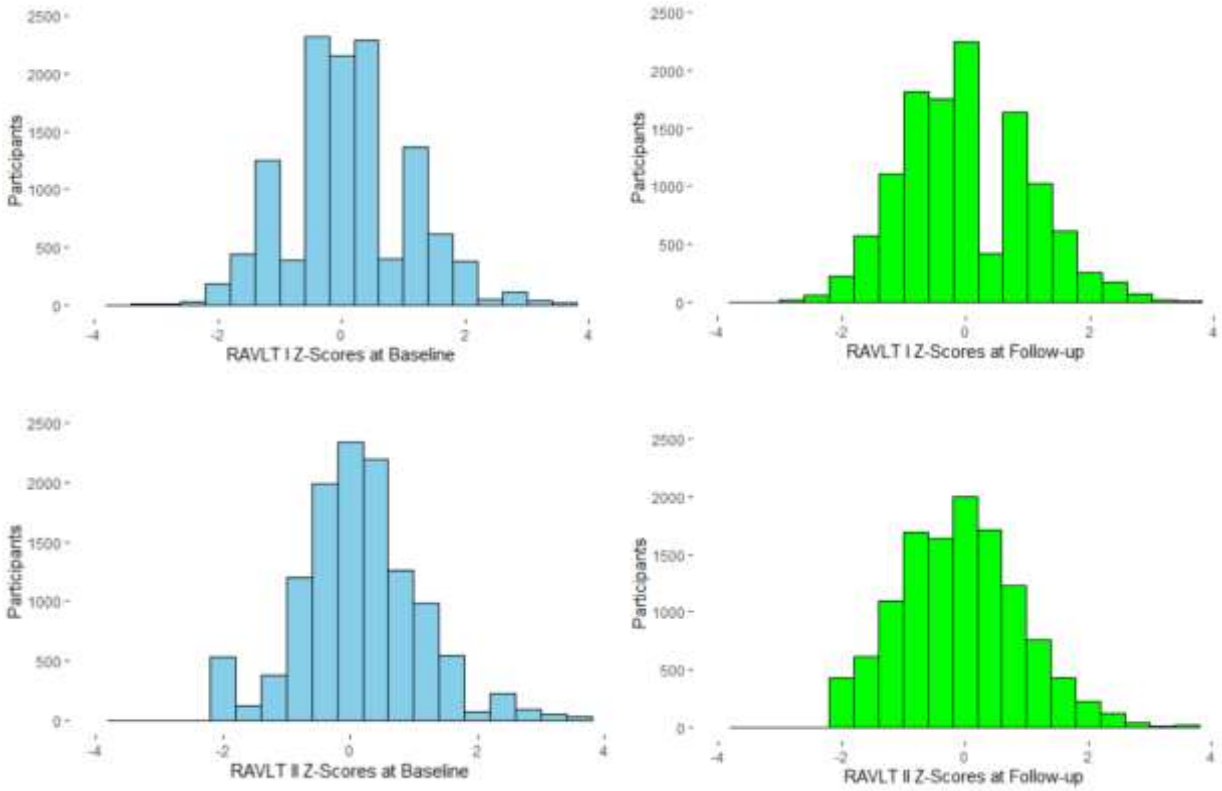
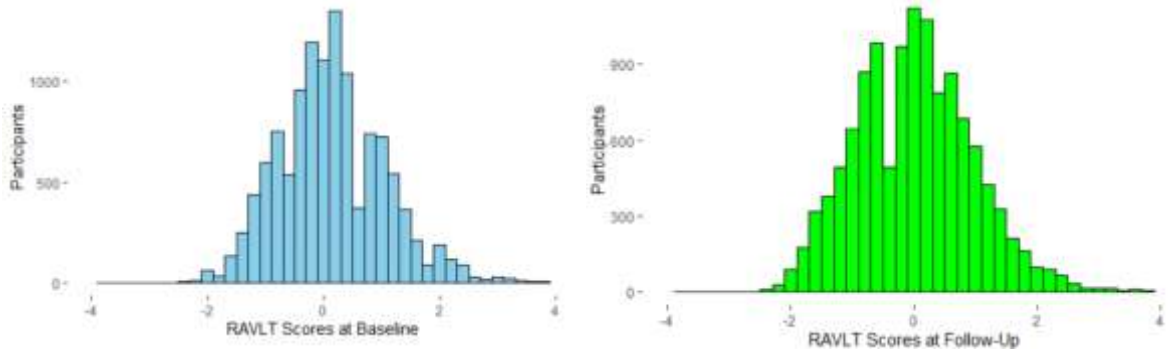


Figure 4.3. Distribution of Combined RAVLT I/II Z-Scores at Baseline and Follow-up



4.1.4. Distribution of Memory Change Scores

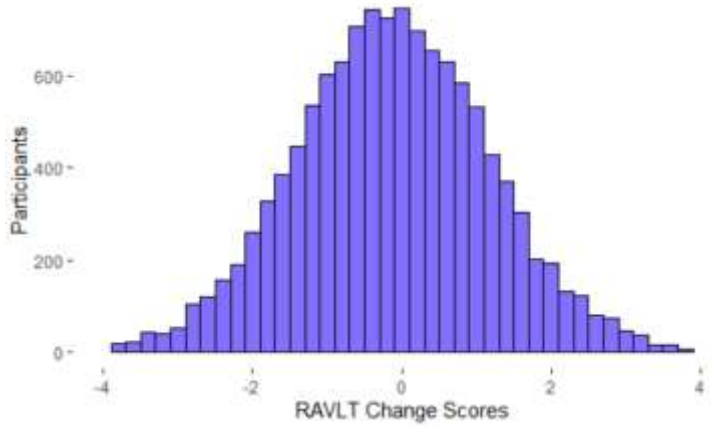
Weighted RAVLT change scores (RAVLT z-score at follow-up – RAVLT z-score at baseline), were normally distributed (mean: -0.24; 95% CI: -0.27, -0.21) (Table 4.9 and Figure 4.4). This indicated that an average participant's combined RAVLT I/II z-score decreased between baseline and follow-up. In total, combined RAVLT I/II z-scores declined for 6,499 out of 12,011 participants (54.11%) in the analytical sample over three years. In weighted distribution, 57.13% of the participants experienced declines in their combined memory scores.

Table 4.9. Distribution of RAVLT Change Scores

		Mean (SD) (95% CI)	Median (IQR)	Minimum	Maximum
RAVLT change	Unweighted	-0.13 (1.31) (-0.16, -0.11)	-0.13 (1.76)	-5.44	4.73
	Weighted	-0.24 (0.01*) (-0.27, -0.21)	-0.23 (1.72)	-5.44	4.73

RAVLT: Rey Auditory Verbal Learning Test;
SD: Standard deviation; * Standard error of mean
CI: confidence interval; IQR: inter-quartile range

Figure 4.4. Distribution of Weighted RAVLT Change Scores



Weighted distribution of RAVLT change scores showed differences by age group and by sex. Both the mean and median RAVLT change scores were largest negative in the 45-54 years age group, indicating the largest decline in memory over three years of follow-up among all four

age groups (negative change score means a decline between baseline and follow-up). Conversely, the largest positive change scores were observed in the ≥ 75 years age group, indicating the greatest improvement in memory (positive change score means an improvement between baseline and follow-up) over follow-up among the age groups (Table 4.10). The RAVLT change scores increased with each older age group. Turning to sex, female participants reported substantially larger negative change scores compared to male participants (Table 4.11).

Table 4.10. Distribution of RAVLT Change Scores by Age Group (Weighted)

RAVLT Change Score	45-54 years (n = 776,340)	55-64 years (n = 502,440)	65-74 years (n = 263,418)	≥ 75 years (n = 107,522)
Mean (SEM)	-0.44 (0.03)	-0.23 (0.02)	0.04 (0.03)	0.42 (0.04)
Median (IQR)	-0.43 (1.71)	-0.24 (1.73)	0.03 (1.70)	0.41 (1.47)

SEM: Standard Error of Mean; IQR: Inter-Quartile Range

Table 4.11. Distribution of RAVLT Change Scores by Sex (Weighted)

RAVLT Change Score	Male (n = 827,099)	Female (n = 822,619)
Mean (SEM)	-0.02 (0.02)	-0.47 (0.02)
Median (IQR)	-0.02 (1.68)	-0.46 (1.73)

SEM: Standard Error of Mean; IQR: Inter-Quartile Range

4.2. Regression Analysis

4.2.1. Base Models

Base models produced small regression coefficients for FSS. The range of the coefficients was narrowly clustered between 0.05 to 0.08 (Table 4.12). Positive regression coefficients indicated high versus low baseline FSS score was associated with an increase in RAVLT score between baseline and follow-up. Larger positive regression coefficients represented greater increases in RAVLT score over follow-up. The magnitudes of the regression

coefficients were small because the increases in RAVLT change scores were less than one point for approximately half of the participants in whom the change scores increased.

Tangible support produced the largest and only statistically significant regression coefficient across all base models. Baseline RAVLT score was a significant predictor of the change score in all models, while sex, age, and province of residence did not show significant associations. The adjusted R^2 value in all of the models was 0.49.

Table 4.12. Base Regression Models for the Association between FSS and RAVLT Change

	Overall FSS β (95% CI)	EMI β (95% CI)	AFF β (95% CI)	TAN β (95% CI)	POS β (95% CI)
R^2	0.4911	0.4911	0.4911	0.4913	0.4911
Adjusted R^2	0.4906	0.4906	0.4906	0.4908	0.4906
High FSS (vs. low)	0.06 (-0.02, 0.14)	0.05 (-0.03, 0.12)	0.05 (-0.01, 0.12)	**0.08 (0.02, 0.14)**	0.05 (-0.02, 0.11)
Baseline RAVLT	**-1.01 (-1.03, -0.99)**	**-1.01 (-1.03, -0.99)**	**-1.01 (-1.03, -0.99)**	**-1.01 (-1.03, -0.99)**	**-1.01 (-1.03, -0.99)**
Sex (vs. male)					
Female	0.00 (-0.04, 0.04)	0.00 (-0.04, 0.04)	0.00 (-0.04, 0.04)	0.00 (-0.03, 0.04)	0.00 (-0.04, 0.04)
Age (vs. 45-54 years)					
55-64 years	-0.08 (-0.05, 0.04)	-0.01 (-0.05, 0.04)	-0.01 (-0.05, 0.04)	-0.01 (-0.05, 0.04)	-0.01 (-0.05, 0.04)
65-74 years	-0.02 (-0.07, 0.03)	-0.02 (-0.07, 0.03)	-0.02 (-0.07, 0.03)	-0.02 (-0.07, 0.03)	-0.02 (-0.07, 0.03)
≥ 75 years	-0.01 (-0.08, 0.05)	-0.01 (-0.08, 0.05)	-0.01 (-0.08, 0.05)	-0.01 (-0.08, 0.05)	-0.02 (-0.08, 0.05)
Province (vs. Ontario)					
Alberta	0.00 (-0.07, 0.07)	0.00 (-0.07, 0.07)	0.00 (-0.07, 0.07)	0.00 (-0.07, 0.08)	0.00 (-0.07, 0.07)
British Columbia	-0.04 (-0.10, 0.02)	-0.04 (-0.10, 0.02)	-0.04 (-0.10, 0.02)	-0.04 (-0.09, 0.02)	-0.04 (-0.10, 0.02)
Manitoba	0.04 (-0.03, 0.11)	0.04 (-0.03, 0.11)	0.04 (-0.03, 0.11)	0.04 (-0.03, 0.11)	0.04 (-0.03, 0.11)
Newfoundland & Labrador	0.02 (-0.06, 0.10)	0.02 (-0.06, 0.10)	0.02 (-0.06, 0.10)	0.02 (-0.06, 0.10)	0.02 (-0.06, 0.10)
Nova Scotia	-0.01 (-0.08, 0.07)	-0.01 (-0.08, 0.07)	-0.00 (-0.08, 0.07)	-0.01 (-0.08, 0.07)	-0.01 (-0.08, 0.07)
Quebec	-0.03 (-0.09, 0.03)	-0.03 (-0.09, 0.03)	-0.03 (-0.08, 0.03)	-0.03 (-0.09, 0.03)	-0.03 (-0.09, 0.03)

Base Model: MOS-SSS variable, baseline RAVLT score, age, sex, and province
FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support
TAN: Tangible Support; POS: Positive Social Interactions
β: regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

4.2.2. Full Models

4.2.2.1. Unstratified

Regression coefficients for FSS in the fully adjusted models ranged from 0.03 to 0.07. Again, the model for tangible support produced the largest and the only statistically significant regression coefficient at the 5% level (Table 4.13). Similar to the base model, baseline RAVLT score was a significant predictor of the change scores across all of the full models (β = -1.01, 95% CI: -1.04, -0.99). Occasional alcohol use was also a statistically significant predictor across all of the fully adjusted models; however, its regression coefficient was small in magnitude and the lower bound of the confidence interval was slightly above the null value at the fourth decimal place (β = 0.08, 95% CI: 0.00, 0.16).

The adjusted R^2 value in all of the models was 0.49. The full models produced residual plots whose points were randomly scattered around the 0 value of the y-axis, thereby indicating good model fit. The observed versus predicted plots showed trends suggesting the linear models fit the data. These plots are shown in Appendix I.

Table 4.13. Fully Adjusted Models for the Association between FSS and RAVLT Change

	Overall FSS β (95% CI)	EMI β (95% CI)	AFF β (95% CI)	TAN β (95% CI)	POS β (95% CI)
R^2	0.4920	0.4920	0.4920	0.4921	0.4920
Adjusted R^2	0.4907	0.4907	0.4907	0.4908	0.4907
High FSS (vs. low)	0.04 (-0.04, 0.13)	0.03 (-0.05, 0.11)	0.04 (-0.04, 0.11)	**0.07** **(0.01, 0.14)**	0.03 (-0.04, 0.10)
Baseline RAVLT	**-1.01** **(-1.04, -0.99)**	**-1.01** **(-1.04, -0.99)**	**-1.01** **(-1.04, -0.99)**	**-1.01** **(-1.04, -0.99)**	**-1.01** **(-1.04, -0.99)**
Sex (vs. male)					
Female	0.01 (-0.03, 0.05)	0.01 (-0.03, 0.05)	0.01 (-0.03, 0.05)	0.01 (-0.03, 0.05)	0.01 (-0.03, 0.05)
Age (vs. 45-54 years)					
55-64 years	-0.00 (-0.05, 0.04)	-0.00 (-0.05, 0.04)	-0.00 (-0.05, 0.04)	-0.00 (-0.05, 0.04)	-0.00 (-0.05, 0.04)
65-74 years	-0.00 (-0.05, 0.05)	-0.00 (-0.07, 0.05)	-0.00 (-0.06, 0.05)	-0.01 (-0.06, 0.05)	-0.00 (-0.06, 0.05)
≥ 75 years	0.01 (-0.07, 0.09)	0.01 (-0.06, 0.09)	0.01 (-0.06, 0.08)	0.01 (-0.06, 0.08)	0.01 (-0.06, 0.08)
Province (vs. Ontario)					
Alberta	-0.00 (-0.08, 0.07)	-0.00 (-0.08, 0.07)	-0.00 (-0.08, 0.07)	-0.00 (-0.08, 0.07)	-0.00 (-0.08, 0.07)
British Columbia	-0.03 (-0.09, 0.02)	-0.03 (-0.09, 0.02)	-0.03 (-0.09, 0.02)	-0.03 (-0.09, 0.02)	-0.03 (-0.09, 0.02)
Manitoba	0.04 (-0.03, 0.12)	0.04 (-0.03, 0.12)	0.04 (-0.03, 0.12)	0.04 (-0.03, 0.12)	0.04 (-0.03, 0.12)
Newfoundland and Labrador	0.01 (-0.07, 0.09)	0.01 (-0.07, 0.09)	0.01 (-0.07, 0.09)	0.01 (-0.07, 0.09)	0.01 (-0.07, 0.09)
Nova Scotia	0.00 (-0.08, 0.08)	0.00 (-0.08, 0.08)	0.00 (-0.08, 0.08)	-0.00 (-0.08, 0.08)	0.00 (-0.08, 0.08)
Quebec	-0.02 (-0.08, 0.04)	-0.02 (-0.08, 0.04)	-0.02 (-0.08, 0.04)	-0.02 (-0.08, 0.04)	-0.02 (-0.08, 0.04)

Table 4.13. (Cont'd) Fully Adjusted Models for the Association between FSS and RAVLT Change

	Overall FSS β (95% CI)	EMI β (95% CI)	AFF β (95% CI)	TAN β (95% CI)	POS β (95% CI)
Education (vs. less than secondary)					
Secondary education	0.10 (-0.01, 0.21)	0.10 (-0.01, 0.21)	0.10 (-0.01, 0.21)	0.10 (-0.01, 0.21)	0.10 (-0.01, 0.21)
Some post-secondary education	0.08 (-0.03, 0.19)	0.08 (-0.03, 0.19)	0.08 (-0.03, 0.19)	0.08 (-0.03, 0.19)	0.08 (-0.03, 0.19)
Post-secondary education	0.07 (-0.02, 0.16)	0.07 (-0.02, 0.16)	0.07 (-0.02, 0.16)	0.07 (-0.02, 0.16)	0.07 (-0.02, 0.16)
Annual household income (vs. ≤ $19,999)					
$20,000 - $49,999	-0.05 (-0.16, 0.06)	-0.05 (-0.05, 0.06)	-0.05 (-0.16, 0.06)	-0.05 (-0.16, 0.06)	-0.05 (-0.16, 0.06)
$50,000 - $99,999	-0.02 (-0.13, 0.09)	-0.02 (-0.13, 0.09)	-0.02 (-0.13, 0.09)	-0.02 (-0.13, 0.09)	-0.02 (-0.13, 0.09)
$100,000 – $149,999	0.00 (-0.11, 0.12)	0.01 (-0.11, 0.12)	0.00 (-0.11, 0.12)	0.00 (-0.11, 0.12)	0.00 (-0.11, 0.12)
≥ $150,000	0.02 (-0.10, 0.14)	0.02 (-0.10, 0.14)	0.02 (-0.10, 0.14)	0.02 (-0.10, 0.14)	0.02 (-0.10, 0.14)
Marital status (vs. married/common-law)					
Single, widowed, divorced, separated	-0.00 (-0.07, 0.07)	-0.00 (-0.07, 0.06)	-0.00 (-0.07, 0.07)	0.00 (-0.07, 0.07)	-0.00 (-0.07, 0.07)
Living arrangement (vs. living alone)					
Living with someone	0.00 (-0.07, 0.07)	0.00 (-0.07, 0.08)	-0.00 (-0.08, 0.07)	-0.01 (-0.08, 0.07)	0.00 (-0.07, 0.08)
Functional status (vs. no impairment)					
Mild impairment	-0.02 (-0.10, 0.06)	-0.02 (-0.10, 0.06)	-0.02 (-0.10, 0.06)	-0.02 (-0.10, 0.06)	-0.02 (-0.10, 0.06)
Moderate, severe total impairment	-0.18 (-0.54, 0.17)	-0.18 (-0.54, 0.17)	-0.18 (-0.54, 0.17)	-0.19 (-0.54, 0.17)	-0.18 (-0.53, 0.17)
Chronic conditions (vs. no conditions)					
1 chronic condition	0.01 (-0.04, 0.05)	0.01 (-0.04, 0.05)	0.01 (-0.04, 0.05)	0.01 (-0.04, 0.05)	0.01 (-0.04, 0.05)
2 chronic conditions	-0.02 (-0.08, 0.03)	-0.02 (-0.08, 0.03)	-0.02 (-0.08, 0.03)	-0.02 (-0.08, 0.03)	-0.02 (-0.08, 0.03)
≥ 3 chronic conditions	0.03 (-0.04, 0.09)	0.03 (-0.04, 0.09)	0.03 (-0.04, 0.09)	0.03 (-0.04, 0.09)	0.03 (-0.04, 0.09)

Table 4.13. (Cont'd) Fully Adjusted Models for the Association between FSS and RAVLT Change

	Overall FSS β (95% CI)	EMI β (95% CI)	AFF β (95% CI)	TAN β (95% CI)	POS β (95% CI)
Depressive symptoms	-0.00 (-0.01, 0.00)	-0.00 (-0.01, 0.00)	-0.00 (-0.01, 0.00)	-0.00 (-0.01, 0.00)	-0.00 (-0.01, 0.00)
Smoking status (vs. never smoker)					
Former smoker	0.02 (-0.03, 0.06)	0.02 (-0.03, 0.06)	0.02 (-0.03, 0.06)	0.01 (-0.03, 0.06)	0.02 (-0.03, 0.06)
Current smoker	0.05 (-0.02, 0.13)	0.05 (-0.02, 0.13)	0.05 (-0.02, 0.13)	0.05 (-0.02, 0.13)	0.05 (-0.02, 0.13)
Alcohol use (vs. no alcohol use)					
Occasional use	**0.08 (0.00, 0.16)**	**0.08 (0.00, 0.16)**	**0.08 (0.00, 0.16)**	**0.08 (0.00, 0.16)**	**0.08 (0.00, 0.16)**
Regular use	0.03 (-0.03, 0.09)	0.03 (-0.03, 0.09)	0.03 (-0.03, 0.09)	0.03 (-0.03, 0.09)	0.03 (-0.03, 0.09)

Full Model: Base model + sociodemographic covariates (education, annual household income, marital status, living arrangement) + health covariates (functional status, chronic conditions, depressive symptoms) + lifestyle covariates (smoking status, alcohol use)
FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support; TAN: Tangible Support; POS: Positive Social Interactions
β: regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

4.2.2.2. Stratified by Age

After stratification of the full models by age (Appendix J), the regression coefficients for FSS were observed to vary across the age groups in a range from -0.08 to 0.12; however, none of the coefficients were statistically significant at the 5% level (Table 4.14). The adjusted R^2 ranged from 0.42 to 0.49, with the value decreasing for older age groups. The stratified models for the oldest age group produced the widest confidence intervals.

Table 4.14. Association between FSS and RAVLT Change Stratified by Age Group

High FSS (vs. low)	**Age Group**			
	45-54 years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
High Overall FSS	0.04 (-0.12, 0.20)	0.10 (-0.03, 0.22)	-0.07 (-0.24, 0.10)	-0.05 (-0.25, 0.15)
High Emotional/Informational Support	0.08 (-0.07, 0.23)	-0.04 (-0.16, 0.07)	-0.00 (-0.13, 0.13)	0.08 (-0.09, 0.26)
High Affectionate Support	0.03 (-0.11, 0.16)	0.10 (-0.01, 0.21)	-0.08 (-0.23, 0.08)	0.03 (-0.18, 0.24)
High Tangible Support	0.12 (-0.01, 0.24)	0.06 (-0.05, 0.16)	-0.02 (-0.14, 0.11)	0.10 (-0.07, 0.27)
High Positive Social Interactions	0.00 (-0.12, 0.12)	0.06 (-0.05, 0.17)	0.08 (-0.06, 0.23)	-0.05 (-0.24, 0.14)

Full Model: Base model + sociodemographic covariates (education, annual household income, marital status, living arrangement) + health covariates (functional status, chronic conditions, depressive symptoms) + lifestyle covariates (smoking status, alcohol use)
FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support; TAN: Tangible Support; POS: Positive Social Interactions
β: regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

4.2.2.3. Stratified by Sex

Stratification by sex (Appendix K) produced regression coefficients that varied between 0.03 and 0.11 for men, and -0.01 to 0.06 for women. Tangible support in the male stratum produced the largest and the only statistically significant effect (Table 4.15). The adjusted R^2 was slightly higher for females (R^2 = 0.4943-0.4944) compared to males (R^2 = 0.4607-0.4610).

Table 4.15. Association between FSS and RAVLT Change Stratified by Sex

High FSS (vs. low)	Male β (95% CI)	Female β (95% CI)
High Overall FSS	0.10 (-0.01, 0.22)	-0.01 (-0.13, 0.10)
High Emotional/Informational Support	0.03 (-0.08, 0.14)	0.03 (-0.08, 0.13)
High Affectionate Support	0.03 (-0.07, 0.14)	0.04 (-0.06, 0.15)
High Tangible Support	**0.11** **(0.01, 0.22)**	0.06 (-0.03, 0.14)
High Positive Social Interactions	0.06 (-0.04, 0.16)	-0.00 (-0.10, 0.10)

Full Model: Base model + sociodemographic covariates (education, annual household income, marital status, living arrangement) + health covariates (functional status, chronic conditions, depressive symptoms) + lifestyle covariates (smoking status, alcohol use)
FSS: Functional Social Support; EMI: Emotional/Informational Support;
AFF: Affectionate Support; TAN: Tangible Support; POS: Positive Social Interactions
β: regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

4.3. Missing Data Analyses

4.3.1. Missing Values for Memory

Participants with missing RAVLT values at baseline reported lower scores on all five FSS variables compared to participants who had non-missing RAVLT values (Table 4.16). At the three-year follow-up, participants with missing RAVLT values reported equal or lower baseline FSS scores than participants with non-missing values.

4.4.2. Missing Values in Functional Social Support

Compared to participants with complete baseline FSS scores, participants with missing baseline FSS scores reported lower mean RAVLT baseline values, but slightly higher mean RAVLT follow-up values. This observation was consistent across all five FSS variables (Table 4.17). The differences in the RAVLT follow-up scores between the two FSS groups were not statistically significant for affectionate support, tangible support, and positive social interactions.

For overall FSS and emotional/informational support, the difference between the two FSS groups were statistically significant.

Table 4.16. Comparison of FSS Scores Among Participants with Complete versus Missing RAVLT Scores

	Baseline			Follow-up		
	Complete n = 12,011	Missing n = 1,331		Complete n = 12,011	Missing n = 6,468	
	Median (IQR)	Median (IQR)	p-value	Median (IQR)	Median (IQR)	p-value
Overall FSS	4.47 (0.89)	4.26 (1.06)	< .0001	4.47 (0.89)	4.42 (0.95)	<.0001
EMI	4.38 (1.00)	4.13 (1.12)	< .0001	4.38 (1.00)	4.38 (1.13)	<.0001
AFF	5.00 (0.67)	4.67 (1.00)	< .0001	5.00 (0.67)	5.00 (1.00)	0.0010
TAN	4.50 (1.00)	4.25 (1.50)	< .0001	4.50 (1.00)	4.50 (1.25)	0.0002
POS	4.67 (1.00)	4.25 (1.00)	< .0001	4.67 (1.00)	4.25 (1.25)	< .0001

IQR: Inter-Quartile Range; RAVLT: Rey Auditory Verbal Learning Test; FSS: Functional Social Support;
EMI: Emotional/Informational Support; AFF: Affectionate Support; TAN: Tangible Support; POS: Positive Social Interactions

Table 4.17. Comparison of RAVLT Scores Among Participants with Complete versus Missing FSS Scores

	Complete Mean (SD)	Missing Mean (SD)	p-value
Overall FSS	n = 12,011	n = 602	
RAVLT baseline	0.14 (0.91)	-0.44 (0.89)	< .0001
RAVLT follow-up	0.00 (0.94)	0.09 (0.95)	0.0330
EMI	n = 12,011	n = 354	
RAVLT baseline	0.14 (0.91)	-0.47 (0.88)	< .0001
RAVLT follow-up	0.00 (0.94)	0.11 (0.96)	0.0285
AFF	n = 12,011	n = 128	
RAVLT baseline	0.14 (0.91)	-0.47 (0.84)	< .0001
RAVLT follow-up	0.00 (0.94)	0.16 (1.05)	0.1570
TAN	n =12,011	n = 273	
RAVLT baseline	0.14 (0.91)	-0.40 (0.92)	< .0001
RAVLT follow-up	0.00 (0.94)	0.04 (0.90)	0.4247
POS	n =12,011	n = 173	
RAVLT baseline	0.14 (0.91)	-0.44 (0.95)	<.0001
RAVLT follow-up	0.00 (0.94)	0.11 (0.98)	0.1638

SD: Standard Deviation
RAVLT: Rey Auditory Verbal Learning Test
FSS: Functional Social Support; EMI: Emotional/Informational Support; AFF: Affectionate Support
TAN: Tangible Support; POS: Positive Social Interactions

5.0. Discussion

5.1. Summary of Findings

5.1.1. Research Question (1)

Is baseline level of FSS (overall and subtypes) associated with changes in memory score over three years of follow-up in community-dwelling men and women aged between 45 and 85 years?

All base models produced small non-significant (yet positive) estimates for the effect of FSS on memory change. The generally small magnitude of the regression coefficients may be due to the roughly even proportions of negative and positive change scores among the participants.

Among the FSS subtypes, tangible support (the provision of physical help when needed) produced the largest and the only statistically significant regression coefficient ($\beta = 0.08$, 95% CI: 0.02, 0.14), indicating that a high level of tangible support, compared to a low level, was associated with positive memory change scores. Since memory change scores were computed as follow-up score – baseline score, positive change scores indicate improvements in combined RAVLT scores over three years. While the literature is equivocal[94,107,109] regarding the effect of tangible support on cognition, this type of support may relieve stress directly through problem resolution (e.g., finding someone to prepare meals) or indirectly through permitting recipients to engage in leisure or similar activities after problem resolution.[85]

5.1.2. Research Question (2)

Are the associations between FSS and memory score maintained after controlling for sociodemographic, health, and lifestyle variables?

The regression coefficients and their confidence intervals in the fully adjusted models were comparable to those of the base models. Tangible support continued to be the only FSS subtype with a statistically significant effect on memory change over three years ($\beta = 0.07$, 95% CI: (0.01, 0.14)).

5.1.3. Research Question (3)

Are the associations modified by age and sex?

Evidence for effect modification by age and sex was equivocal. Across all age groups, the regression coefficients for FSS had wide confidence intervals containing zero, with the width of the confidence intervals increasing for older age groups. Although not statistically significant, based on the magnitude of regression coefficients, tangible support may have the largest positive effect on memory for 45-54 years and $\geq$ 75 years groups, while affectionate support and positive social interactions may be the most beneficial FSS subtype for 55-64 years and 65-74 years groups.

Between the sexes, the pattern of association was not consistent. While all but one model (tangible support for male) produced non-statistically significant regression coefficients, the magnitudes of these coefficients were comparable or smaller for the female stratum compared to the male stratum. For males, a high level of tangible support was associated with positive memory change scores over three years. Tangible support also produced the largest regression coefficient estimate for females.

5.2. Explanation of Findings

5.2.1. Association between Functional Social Support and Memory

The positive effect of FSS (overall and subtypes) on memory was largely equivocal. Although the regression coefficients mainly pointed to an association between high versus low FSS and improved memory over time, the coefficients were small in magnitude and most (tangible support excepted) were not statistically significant.

The findings of this thesis may be explained by several factors. First, the analytical sample used in the thesis was younger and physically healthier than the samples recruited into many other studies in the field. Most of the published literature included individuals aged 60 years or older (30/48 studies) with multiple age-related chronic conditions. In this thesis, over 77% of the analytical sample was under the age of 65 years (mean age = 61 years), approximately 72% had one or no chronic conditions, and about 95% had no functional impairment at baseline. As such, the participants in the analytical sample may have needed less FSS than the typical samples recruited into other studies, thereby diminishing the observed role of FSS in memory function. Moreover, since younger individuals generally exhibit fewer signs of age-related cognitive deficits than older persons,[22] the analytical sample drawn from the baseline CLSA dataset may not have been optimal for assessing changes in memory over a three year follow-up period.

Second, a very large proportion of the analytical sample was cognitively healthy because the CLSA screened out persons with overt cognitive impairment at recruitment. Also, the level of commitment required to participate in the CLSA's Comprehensive Cohort may have de-incentivised older adults with minute, though burgeoning, cognitive challenges from considering participation in the study, thereby furthering the recruitment of a highly selective subgroup of

cognitively healthy older persons. In fact, selective recruitment of cognitively healthy individuals in the older age group was evident in that mean and median memory change scores increased in older age group and the proportion of individuals with improved memory scores was twice as large in the older- (≥ 65 years) compared to the middle-age (45-64 years) group. The healthy nature of the sample created a situation whereby most participants' memory function remained stable, thereby preventing the thesis candidate from assessing whether FSS could preserve or promote memory function.

Third, given the cognitively healthy analytical sample, a three-year follow-up was unlikely to be long enough to detect changes in memory. Other studies with relatively short to medium follow-ups have also found muted results. Jacqmin-Gadda et al.'s[199] five-year study of 2,537 French adults aged 65 years or older found very small declines in cognitive performance among individuals who were free of cognitive impairment at baseline. Additionally, delayed memory scores in cognitively healthy samples exhibited unreliable or very small changes over three years among 327 Swedish adults aged 75 years or older.[200] The Swedish study also reported no changes in immediate recall score.[200] Based on a different six-year analysis of 528 Swedish adults aged 75 years or older who were free of dementia at baseline, Small et al. suggested the magnitudes of cognitive impairment may be relatively stable and without manifestation of detectable symptoms until shortly before clinical diagnosis is made.[22]

The existing literature and the findings from the thesis suggest longer follow-ups using multiple time points are necessary to examine the association between FSS and memory changes in the CLSA dataset. Indeed, studies with longer periods of observation tend to report protective effects for overall FSS on memory. Liao et al.[92] found that higher social support predicted slower memory decline over eight years among British adults aged 50 years or older. Seeman et al.[6] also

reported both better functional and structural social support were significant predictors of maintenance of better cognitive function, independent of other variables, over ten years among Americans between the ages of 25 and 74 years.

Published research does not indicate the inflection point for suitable lengths of follow-up to investigate the association between FSS and memory. Wilson et al.[93] found higher levels of negative social relationships (e.g., perceived rejection or neglect, failure by others to provide help when needed, unsympathetic or insensitive behavior from others, etc.) at baseline were associated with rapid declines in episodic, semantic, and working memory over five years among American adults aged 50 years or older. Systematic reviews[54,86] also reported positive associations between overall FSS and memory in longitudinal studies with five or more years of follow-up.

To the best of the thesis candidate's knowledge, only five studies[87,88,99,102,112] investigated the association between FSS and cognitive function among community-dwelling middle-aged and older adults in a longitudinal design. The first of these studies, by Liao et al.,[92] included 10,241 adults aged 50 years or older who were followed for over eight years in the ELSA. The authors found that positive social support from a significant other (measured via an interview and questionnaire) was associated with slower declines on a battery of executive function and memory performance tests for males; they also reported that higher positive social support from children and friends – but not from significant others – predicted better executive function for females. Based on the same ELSA sample over a ten-year period, Khondoker et al.[110] found that positive social support from children was associated with a lower risk of developing dementia, and negative social support from children and immediate family increased the risk.

Ellwardt et al.[107] studied 2,255 individuals aged between 55 and 85 years (mean age = 63 years) in the Netherlands for six years. They reported that while emotional support (i.e., the extent to which participants talked with their close social contacts about personal experiences and feelings in the past year)[202] was most strongly associated with higher cognitive function for adults aged 65 years or older, more tangible support predicted faster declines in cognition in the same age group.[107] Wilson et al. found that negative social interactions (measured via a psychometry scale[203]) were associated with lower global cognition, higher risks of developing mild cognitive impairment, and rapid cognitive decline in a sample of 529 American adults aged 50 or older for 4.8 years.[93] Zuelsdorff et al.[119] also reported a positive relationship between perceived social support and psychomotor speed in their five-year study of 623 middle-aged and older individuals in the US.

While all of these studies found positive associations between FSS and cognitive function, they may not be directly comparable to the results of this thesis because they utilized different constructs to measure FSS and cognition, and they had longer follow-up periods.

5.2.1.1. Inverse or Null Associations between Functional Social Support and Cognition

Some published articles reported inverse associations between FSS and cognition.[4,6,12,19–21] Pillemer et al.[97] recently found that a higher level of FSS (measured via the MOS–SSS) was associated with significantly higher risks of incident cognitive impairment (measured via the Repeatable Battery for the Assessment of Neuropsychological Status[205]) over four years among 493 community-dwelling, cognitively healthy adults aged 65 years or older. This observation was consistent for all FSS variables, except emotional/informational support, for which no significant association was found. Sims et al.'s[57] cross-sectional study of 175 healthy, community-dwelling adults (mean age = 66 years) also found that tangible support and other

measures of social support, i.e., appraisal support, belonging support, and self-esteem support (all measured via the Interpersonal Support Evaluation List[206]), were inversely associated with nonverbal memory (measured via the Wechsler Memory Scale – Revised[207]) and response inhibition (measured via the Stroop Color-Word Test[208]).

Pillemer et al.[97] and Sims et al.[57] provided multiple explanations for their findings, beginning with the reciprocity theory: the receipt of social support that the recipient cannot reciprocate, due to illness or other limitations, might lead the recipient to experience stress, anxiety, depressive moods, and feelings of burden or uselessness,[57] any of which may adversely affect cognitive function. These authors also felt the distinction between fluid and crystallized intelligence,[209,210] as well as sex differences,[97] could help explain the inverse association. Cognitive skills such as comprehension, short-term memory (measured by the Wechsler Adult Intelligence Scale – Revised[64] and the RAVLT), pattern recognition, and problem-solving represent fluid intelligence, which is a set of innate abilities and does not depend on, and may even be slowed by, "social engagement."[57] Crystallized intelligence, on the other hand, is shaped by structured knowledge that is often acquired within, and may be improved by, social environments such as school and work.[57,209] For men, high levels of tangible support at baseline may indicate incident declines in cognitive function, as men typically have less intensive networks of social support and, in the event of cognitive decline, may actively gather support to maintain their function.[97]

Eisele et al.[204] also found emotional FSS (measured using the Social Support Questionnaire – FSoZu K-14[211]) had no association with cognitive change (measured using a 55-item neuropsychological test battery[212]) in an 18-month follow-up of 1,869 primary care patients aged 75 years or older. Although Eisele et al.'s sample was different from the thesis (i.e., mean

age of 82 years, higher proportion of females [66%], primary care setting, shorter follow-up time), the authors' explanation of their findings could be applied to this thesis, as they believed the detection of cognitive changes using neuropsychological tests would be difficult in non- or pre-pathological stages of cognitive impairment. This is because the noise introduced by random variation in participants' performance on the tests would eclipse any true changes in cognitive function. The authors concluded that longer follow-ups and more marked declines in cognitive change would be needed to ascertain the association between FSS and cognitive function.[204] However, Eisele et al.[204] did not identify the minimum length of time that would qualify as 'longer' follow-up.

Lastly, Dickinson et al.[111] reported that a higher level of emotional support (e.g., feeling listened to by family and friends, as measured by the Duke Social Support Index[213]) was not associated with changes in cognition (measured via multiple tests [64,207,214–216]) over two years of follow-up among Americans aged 60 years or older (n = 213). Zuelsdorff et al.[119] also found that FSS (measured via MOS–SSS) was not associated with memory (measured via RAVLT) over five years of follow-up among middle-aged or older Americans (n = 625). Dickinson et al. believed different memory processes might be affected differently by stress and environmental factors, as they reported links between declining tangible support and lower cognitive function.[111] Zuelsdorff et al. suggested that selection bias may have contributed to their null findings because participants performed better than average on the memory tests.[119]

5.2.2. Association between Functional Social Support and Memory by Age

The findings from this thesis were inconclusive with regard to whether age modified the association between FSS and changes in memory score. While descriptive analyses showed that memory scores increased (improved) for older participants (65-74 years and ≥ 75 years) over

three years, regression analyses adjusting for covariates did not produce consistent patterns or statistically significant findings. The absence of clear signs of effect modification by age in the thesis may be explained by the CLSA's exclusion of persons with overt signs of cognitive impairment at baseline, as well as the likelihood that a highly selective subsample of cognitively healthy older adults agreed to join the study (see Section 5.2). Similar to this thesis, Zuelsdorff et al.[119] attributed the null finding in their study to the sample's higher-than-average performance on a memory test battery.

The published literature is equivocal regarding whether age modifies the association between FSS and cognition. Age was not found to be an effect modifier in a cross-sectional analysis of the CLSA Tracking Cohort[75], nor was it shown to modify any associations in a seven-year study of American adults aged between 70 and 79 years[98] and a five-year report of Americans with a mean age of 72 years.[109] In contrast, Ohman[96] found the cross-sectional association between FSS and delayed memory in the CLSA Comprehensive Cohort was strongest among participants in two age groups, i.e., 45 to 54 years and ≥ 75 years, compared to 55-64 years and 65-74 years.

Two longitudinal studies reported that age modified the association between FSS and cognitive function. Wilson et al.'s five-year study in the United States found a stronger inverse association between FSS and memory function among older versus middle-aged adults.[93] Meanwhile, Seeman et al.'s 10-year study of Americans aged between 25 and 74 years found stronger relationships between global cognition and social engagement (combining structural and functional support) among younger (32 - 44 years and 45 - 54 years) versus older participants (65 - 74 years and 75 years or older).[6] Seeman et al. provided two explanations for their findings: first, older participants with lower levels of social engagement and poorer cognition were more

likely to drop out of the study; second, older participants had a greater mix of competing risk factors undermining cognition, compared to younger participants, independent of social engagement.[6]

5.2.3. Association between Functional Social Support and Memory by Sex

With the possible exception of tangible support, the moderating effect of sex was generally not evident from the analyses. While memory scores declined substantially among females compared to males, regression models yielded comparable estimates of effect for both sexes for emotional/informational support and affectionate support. For overall FSS, tangible support, and positive social interactions, the regression coefficients were somewhat different, but the estimates had comparable or overlapping confidence intervals between both sexes. Tangible support was found to be statistically significantly associated with improved memory for males; however, considering the wide confidence intervals and comparable regression coefficients for males and females, sex did not appear to moderate the association between tangible support and memory change.

In contrast to the thesis, several studies reported a moderating role for sex. Liao et al.'s[92] nine-year analysis of ELSA data found sex moderated the association between FSS (perceived level of positive and negative social support devised from feeling understood, being able to talk about worries, and being able to rely on someone) in 10,241 participants aged 50 years or older. A higher level of positive social support from spouses or partners predicted higher global cognition for men, but lower global cognition for women.[92] The authors also found that negative social support (criticism, feeling let down, annoyance) was associated with more rapid cognitive decline in men compared to women.[92] However, these results are not directly comparable with

the thesis because the MOS–SSS did not specifically measure the extent of positive or negative social support.

In other work, Li et al.'s[95] cross-sectional study of Chinese-American adults aged 60 years or older found that the quality of social relationships, including emotional closeness, was more beneficial for global cognition (measured via the Chinese version of the Mini Mental State Examination[61]) in men compared to women. This was further supported by Ohman,[96] who observed stronger positive associations between FSS (measured via the MOS–SSS) and memory (measured via the RAVLT) among males compared to females in a cross-sectional analysis of the CLSA's Comprehensive Cohort.

While the aforementioned studies suggest that high level versus low level FSS may be more beneficial for men compared to women, Pillemer et al.'s longitudinal study[97] found a higher level of overall FSS, tangible support, and positive social interactions was associated with higher risks of incident cognitive impairment only among males. Pillemer et al.'s earlier cross-sectional study[94] reported stronger associations between emotional/informational support and global cognition among women compared to men.

The literature offers some insights into how men and women differently formulate and benefit from social relations: compared to men, women generally receive more support from diverse sources such as friends, relatives, and children,[92,94,97,104] whereas men depend more on positive social support from their spouses.[92,97] Men also tend to find emotionally-driven or close social relationships with multiple people to be burdensome and stressful,[97] and the quality of spousal relationships may deteriorate more for women than men.[104] Whether these sex-based differences help explain some of the different estimates of effect observed in this thesis is

unclear, as the CLSA did not collect data on the source of FSS or on participants' perceptions of whether they received positive or negative FSS.

Taken together, the findings of this thesis did not suggest clear effects for age and sex on the association between FSS and memory. However, the stability in cognitive function scores reported over three years could have prevented the thesis from adequately measuring effect modification by age and sex. A longer follow-up is needed to further explore effect modification in the CLSA.

5.3. Strengths

This thesis has notable strengths. First, the CLSA covered middle- and older-aged, community-dwelling persons who were recruited in seven out of ten Canadian provinces. This permitted the thesis results to be applicable to a broader target population than most previous studies, whose samples were often restricted to small geographical areas, to persons with specific comorbidities, or to older adults. Second, the longitudinal analysis permitted an examination of the effects of FSS on memory over time, thereby mitigating the possibility of reverse causality bias. Third, the MOS–SSS was a valid and reliable tool for measuring FSS, and it enabled detailed and focused analyses of the subtypes of FSS. This is important given the multitude of approaches used to define and measure FSS in the literature, with some of these approaches being poorly defined or meshed with structural social support.

Fourth, the thesis candidate was able to control for all of the covariates that had been included in previous published studies. In addition to the most widely discussed covariates, e.g., age and sex, she used the literature search to identify important factors such as depressive symptoms, chronic health conditions, marital status, and living arrangements. This approach helped to minimize residual confounding.

Fifth, this thesis adds to the relatively small body of literature about the association between FSS and memory. A majority of the previous research assessed memory as a component of global cognition rather than as a distinct outcome. However, considering the importance of memory loss as the first and often only indicator of cognitive impairment,[22,200] more focused research on this specific cognitive outcome is required in the future. The literature yielded only three studies that examined memory as a single distinctive outcome in relation to FSS. Two of these three studies emerged out of the thesis supervisor's work: Oremus et al.[75] and Ohman[96] undertook cross-sectional studies of the CLSA Tracking and Comprehensive Cohorts, respectively, and concluded that higher levels of FSS were significantly associated with higher RAVLT scores. In another cross-sectional study, Jeong et al.[122] found that a higher level of social support (emotional and tangible support) was associated with lower levels of forgetfulness in 338,659 individuals aged between 65 and 106 years who lived in 105 municipalities in Japan.

5.4. Limitations

The research presented in this thesis has some limitations. First, participants in the CLSA were volunteers who reported higher levels of education, income, and health compared to the average person in the 45- to 85-year age group. These characteristics are known to be positively associated with cognitive function. According to the Canadian Income Survey,[217] the median household income was $56,000 in 2015. This compares with the thesis analytical sample, almost half of whom reported a household income over $100,000 in the same year. The 2016 Census[218] reports that individuals with some post-secondary education or higher accounted for 53.0% and 44.3% of the 45- to 54-year and 55- to 64-year age group, respectively. In the corresponding age groups in the analytical sample, 90.58% and 87.22% reported some post-secondary education or higher.[96]

Volunteer bias was also apparent in the tight and left-skewed distributions of FSS scores at baseline and follow-up. The only other studies[94,97] that used the MOS-SSS scale to measure overall and subtypes of FSS among small samples (n = 355 and 493) of community-dwelling Americans aged 65 years or older reported mean FSS scores ranging from 3.99 to 4.33. The mean FSS scores of the analytical sample ranged from 4.23 to 4.50. Since Comprehensive Cohort participants are required to visit a data collection site, one would expect older participants to have social supports in place to permit them to fulfill this requirement. The resulting skewness of MOS–SSS scores reduced the variability needed to detect differences in memory change scores across the entire FSS spectrum. This skewness may have also diluted the potential to detect effect modification because males, females, and all age groups had similarly high MOS–SSS scores.

Another possible selection bias occurred because CLSA interviewers excluded potential participants who showed signs of cognitive impairment at the baseline recruitment interview. While this eligibility criterion may have been necessary to generate a baseline sample suitable for longitudinal follow-up over a planned period of at least 20 years, it resulted in overrepresentation of a cognitively healthy subset of the target population. This led to stable RAVLT scores at baseline and follow-up (see Section 5.2.1), with reduced variability to observe changes in memory over three years of follow-up.

Second, attrition of participants over the follow-up period may have resulted from a selection bias. In total, 2,332 participants (5.1%) either withdrew from the study before the follow-up or did not provide data at the follow-up. Participants who withdrew were generally older and had lower levels of education and income, and poorer self-rated health.[159] Furthermore, participants who dropped out of the study reported lower FSS and lower cognition. This attrition

was likely to produce a healthier-than-average analytical sample that further reduced the levels of variability that would have been needed to detect the associations of interest.

Third, the percentage of participants with missing memory scores increased from approximately 4% at baseline to 22% at follow-up. Exclusion of participants with missing values on FSS or other covariates further reduced the analytical sample used in this thesis to 40% of the baseline cohort. While the analytical sample was large enough to minimize underpowered analyses, comparison of participants with and without missing values across different variables showed a consistent pattern. Individuals with missing memory scores had a lower level of FSS compared to those with complete memory scores at both time points. Individuals with missing FSS values had lower or comparable memory scores relative to those with complete FSS responses at both time points. Therefore, excluding individuals with missing data may have amplified the selection bias discussed above.

Fourth, the absence of normative data for the MOS-SSS and RAVLT scores enhanced the difficulty of contextualizing the thesis results for public health purposes. Normative data would help interpret scale scores and the magnitudes of regression coefficients in light of benchmarks indicating the types of scores that one would expect in an average population.

Fifth, the z-scores for both memory tests did not change substantially over the three years of follow-up, raising the possibility of practice effects. Evidence shows that repeating a memory test over time can improve memory performance, regardless of whether the test questions are changed or not, because participants may improve their test-taking skills.[19,31]

While practice effects are theoretically possible in the CLSA sample, and they do form a consideration in the development of the cognitive normed scores (Megan O'Connell, personal

communication), most participants would be unlikely to intentionally remember or subconsciously recall a large share of the 15 recorded words that form the RAVLT. Practice effects would be more likely to occur if the RAVLT was administered weekly or monthly compared to once every three years. Since this thesis included only two timepoints of data, participants did not have the opportunity to gain long-term familiarity with the RAVLT. As such, any practice effects in the analytical samples would be unlikely to bias the thesis' results.

5.5. Implications

The equivocal findings of this thesis do not point to a specific set of policy recommendations. However, given tangible support's large and positive effects on memory change for both sexes, practical support programs may be an area of focus, e.g., housekeeping services, deliveries, ridesharing initiatives, and telemedicine.

A number of interventions have been proposed in earlier research to increase FSS among targeted groups or the general population (e.g., buddy programs for seniors,[75] pet therapy,[75,81] psychological counselling for family/spouse,[75] self-help groups[18]), these programs are based on strong magnitudes of association between FSS and cognition identified by multiple studies. Further research with longer follow-up is needed to better understand the association between FSS and memory, as well as the possible moderating effects of age and sex. These deeper findings may contribute to the development of targeted interventions for maintaining cognitive health among subgroups defined by age group or sex.

6.0. Conclusion

This thesis found a weak though generally positive association between FSS and memory over three years of follow-up in Canadians aged between 45 and 85 years. At a descriptive level, RAVLT change scores increased for roughly half of the participants, and decreased for roughly half of the participants, regardless of FSS. This thesis may have been unable to detect clearer associations because it utilized a sample of cognitively healthy participants with high levels of FSS who were followed for a relatively short duration of three years. Whether age and sex moderated the association between FSS and memory change was not clear over the three-year follow-up period available for analysis in this thesis. Longer follow-ups are required to undertake assessments of the relation between FSS and memory in the CLSA dataset.

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Appendices

Appendix A-1. Search Terms Used in the Literature Review

Table A-1. Search Terms Used in the Literature Review

PubMed	PsychINFO
(social environment[mesh] OR social isolation[mesh] OR social support[tiab] OR social environment[tiab] OR social network[tiab] OR social relationship*[tiab] OR social cohesion[tiab] OR community network*[tiab]) AND (cognition[tiab] OR cognitive decline[tiab] OR cognitive function[tiab] OR memory[mesh] OR dementia[mesh] OR memory[tiab] OR dementia*[tiab])	(Abstract: social support* OR Abstract: social engagement* OR Abstract: social relationship* OR Abstract: social environment*) AND (Abstract: cognition OR Abstract: cognitive function OR Abstract: cognitive decline OR Abstract: memory)
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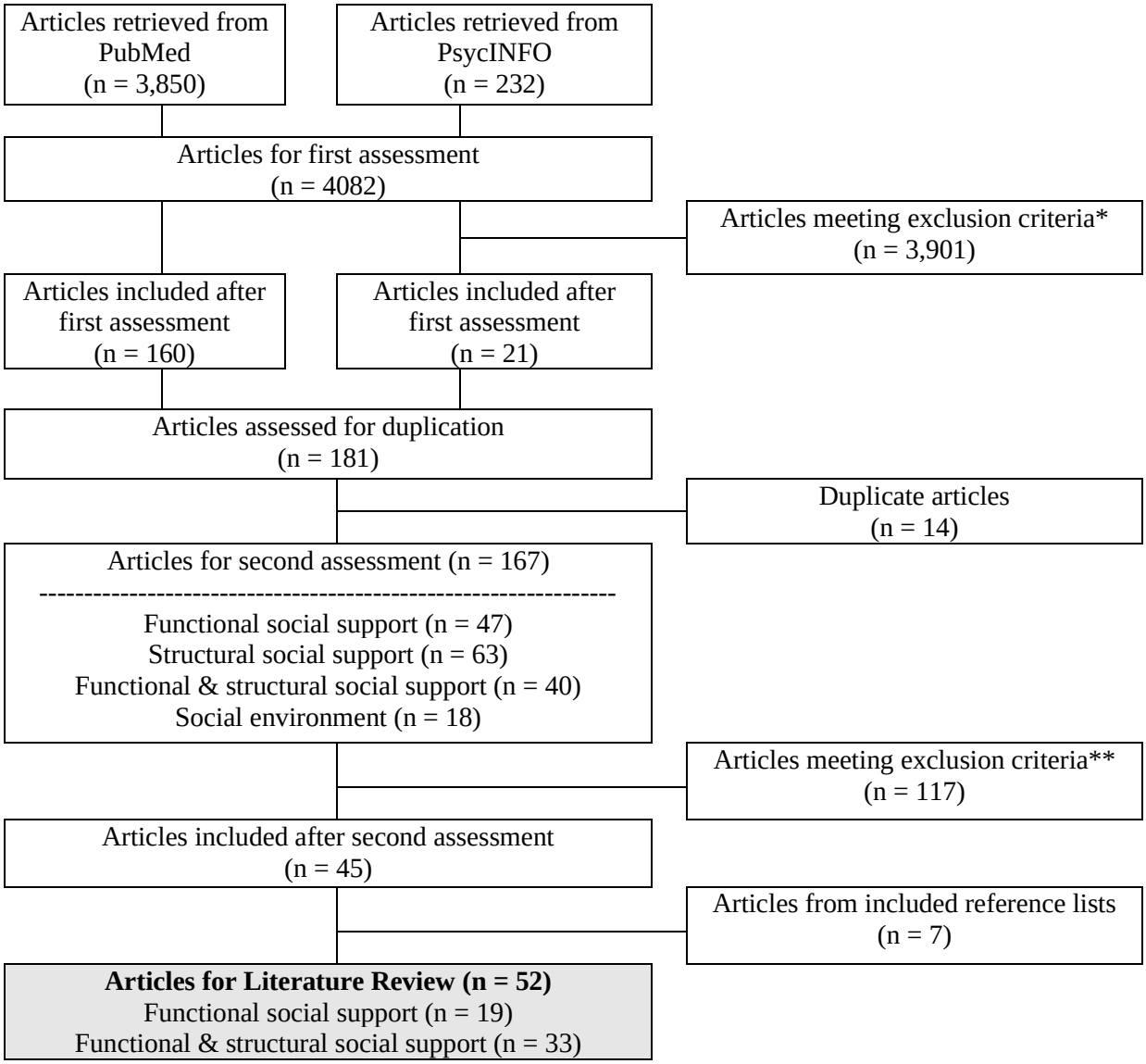
Filtered: journal articles only Filtered: human studies only Filtered: age groups 45 years or older	Excluded: animal studies Excluded: age groups 0-39 years Excluded: qualitative studies Filtered: peer-reviewed journal articles only
Retrieved 3,850 articles (as of March 6, 2021)	Retrieved 232 articles (as of March 6, 2021)

Figure A-1. Literature Search Process



Exclusion criteria*

(1) Study conducted on caregivers.
(2) Predictor variable is neither social support nor cognitive function.
(3) Outcome variable is neither social support nor cognitive function.
(4) Social support is not directly measured.
(5) Study population has been diagnosed with dementia.

Exclusion criteria**

(1) Social support measures include structural aspects only.
(2) Social support measures include collective and/or geospatial aspects only.
(3) Social support measures include negative perceptions and/or loneliness only.
(4) Cognitive function is not measured by validated tools.
(5) Full article is not available in English.

Appendix A-2. Summary of the Literature on the Association between Social Support and Cognitive Function

Table A-2. Summary of the Literature on the Association between Social Support and Cognitive Function

Literature on Functional Social Support and Cognitive Function						
First author	**Title**	**Study design**	**Study population**	**Measures**	**Conclusions & Findings**	**Covariates**
[1] Eisele et al. (2012)	Influence of social support on cognitive change and mortality in old age: results from the prospective multicentre cohort study AgeCoDe	Longitudinal 18 months	1,869 primary care patients (75+), sampled from Ageing, Cognition and Dementia in Primary Care Patients cohort, residing in six German cities (Hamburg, Bonn, Düsseldorf, Leipzig, Mannheim, Munich)	Emotional support: perceived social support measured with 14-item short form of the questionnaire for social support (FSozU K-14) Cognitive function: Structured Interview for the Diagnosis of Dementia of the Alzheimer type, Multi-infarct Dementia and Dementia of other Aetiology (SIDAM)	Perceived social support, understood as the emotional component of social support, was not found to significantly influence cognitive change, mortality, and survival time over the 18 months observation period. None of the three components of emotional support had a significant influence on cognitive change over the 18 months observation period.	Marital status, engagement in social groups, depressive symptoms (GDS), IADL, smoking status, sensory impairment, cognitive activity, physical activity, ability to walk, co-morbidities

[2] Ellwardt et al. (2013)	Does loneliness mediate the relation between social support and cognitive functioning in later life?	Longitudinal 6 years	2,255 individuals aged 55-85 at baseline in the Longitudinal Aging Study Amsterdam, Netherlands (LASA, 1992-1998), followed up every 3 years	Cognition: MMSE (recall, orientation, registration, attention, language, construction), adapted Coding Task (information processing speed), Raven Coloured Progressive Matrices (reasoning) Emotional and instrumental support: questionnaire Loneliness: De Jong Gierveld Loneliness Scale	High level of emotional and instrumental support promoted greater cognitive performance (directly mediated by reduced feeling of loneliness). The protective effect of emotional support was strongest amongst adults aged 65 years and older. Emotional and instrumental support differed in their impact on cognitive functioning: emotional support had direct and indirect influences, whereas instrumental support had only direct influence. Increase in instrumental support did not buffer cognitive decline, instead there were indications for faster decline. Emotionally supportive relationships were stronger protectors against cognitive decline compared to instrumentally supportive relationships.	Age, gender, level of education, physical functioning
[3] Hajek et al. (2020)	Perceived social isolation and cognitive functioning: Longitudinal findings based on the German Ageing Survey	Longitudinal 3 years	6,420 adults (40+) participating in the German Ageing Survey (DEAS) (mean age = 65)	Perceived social isolation: a scale by Bude and Lantermann. (4-items) Cognitive functioning (perceptual motor speed, processing speed of visual perception and information): digit symbol test	Increases in perceived social isolation were associated with decreases in cognitive functioning. Decreases in cognitive functioning were associated with increases in aging and worsening self-rated health, whereas changes in marital status, employment status, income, physical functioning, and physical illnesses were not associated with the outcome measure.	Age, marital status, living arrangement, household net equivalent income, labor force participation, self-rated health, physical functioning, number of physical illness

[4] Holwerda et al. (2014)	Feelings of loneliness, but not social isolation, predict dementia onset: results from the Amsterdam Study of the Elderly (AMSTEL)	Longitudinal 3 years	2,173 community-dwelling older adults (+65) in Amsterdam	Social isolation (living arrangement, marital status, social support availability) Dementia: Geriatric Mental Scale Automated Geriatric Examination for Computer Assisted Taxonomy GSM-AGECAT)	Feeling lonely rather than being alone is associated with an increased risk of clinical dementia in later life, independent of vascular disease, depression and other confounding factors.	Sociodemographic factors, medical conditions, functional status, depression, cognitive functioning
[5] Hughes et al. (2008)	The association between social resources and cognitive change in older adults: Evidence from the Charlotte County Healthy Aging Study	Longitudinal 5 years	217 individuals (mean age = 72.4 years) from the Charlotte County Healthy Aging Study	Cognition: MMSE (general cognitive ability), attention (Stroop Test), perceptual speed (Trail-making Test), delayed free recall, cued recall, and episodic memory (Hopkins Verbal Learning Tests) Social resources: social network of family, social network of friends, emotional support, instrumental support, informational support, satisfaction with support, negative social interactions	More negative social interactions and greater satisfaction with support were associated with better general cognitive ability. This may be the result of negative social interactions providing a greater level of stimulation, which benefits cognitive functioning. Better performance on speed and attention was associated with greater satisfaction with support. Over 5 years, less satisfaction with support was marginally associated with decline in episodic memory performance. Receiving less emotional, instrumental, or informational support was not related to cognitive performance. Age modified the relation between baseline episodic memory performance and emotional support.	Age, gender, education, marital status, residency in Charlotte County, personality (neuroticism, extraversion, openness, agreeableness, conscientiousness)

[6] Huntley et al. (2018)	Online assessment of risk factors for dementia and cognitive function in healthy adults	Cross-sectional	14,201 non-demented individuals (50+) in UK and participating in online PROTECT study (mean age = 62)	Cognitive assessment: episodic memory - Paired Associate Learning Task (PAL); spatial working memory – Self-Ordered Search Task; verbal working memory – Digit Span Task; and verbal reasoning – Grammatical Reasoning Task. Exposure variables: education, smoking, depression, physical activity, perceived social isolation, hypertension, diabetes, obesity, alcohol use, age, gender, heart disease or stroke, marital status.	Absence of a close confiding relationship was significantly associated with poorer performance on all four cognitive tasks. Age was a significant contributor to cognitive function, with each five-year increase in age group, except for the > 90 year group, associated with a significant reduction in score on all four cognitive tasks, compared to the youngest age group	
[7] Khondoker et al. (2017)	Positive and Negative Experiences of Social Support and Risk of Dementia in Later Life: An Investigation Using the English Longitudinal Study of Ageing (ELSA)	Longitudinal 10 years	10,055 dementia-free individuals (50+) in ELSA in the UK, followed up every 2 years	Incident dementia: IQCODE Time-to-dementia Negative/positive social support	Positive social support from children is associated with reduced risk of developing dementia whereas experiences of negative social support from children and other immediate family increase the risk. Irrespective of the source of social support, overall negative support was significantly associated with an increased risk dementia. Effect sizes were generally larger for negative compared with positive social support. Relatively stronger associations for the negative social support relative to the positive support may be indicative of the fact that stress of criticism and lack of reliability are possibly more harmful than the absence of a warm relationship.	Age, sex, net wealth, education, co-morbidities

[8] Liao et al. (2018)	Dynamic longitudinal associations between social support and cognitive function: A prospective investigation of the directionality of associations	Longitudinal 10 years	6,863 individuals (mean age = 55.8) participating in the Whitehall II cohort (1997-2009)	Social support: Close Persons Questionnaire (confiding support, practical support, and negative aspects of close relationships) Cognitive function: executive function – Alice Heim 4-I test, inductive reasoning test, and tests of verbal fluency, phonemic fluency, and semantic fluency Short-term verbal memory	A better cognition at preceding stage was related to less positive changes in confiding support and less negative changes in practical support over the next 5 years. There was no detectable influence from practical support and confiding support on cognition. Negative aspects of close relationships did not show directional relationships either to or from cognition.	Age, sex, ethnicity, longstanding illness, depressive symptoms, prevalent chronic diseases, education, employment grades (socioeconomic position), marital history, identity of the closest person
[9] Oremus et al. (2019)	Social support and cognitive function in middle- and older-aged adults: descriptive analysis of CLSA tracking data	Cross-sectional	21,241 individuals aged 45-85 in Canada	Social support availability: Medical Outcomes Study – Social Support Survey (MOS-SSS) Cognitive function: Rey Auditory Verbal Learning Test (RAVLT), Mental Alternation Test, Animal Naming Test	The proportion of participants with low global cognitive function was greater among those reporting low global social support availability. Stratifications by sex, age group, region of residence, urban vs. rural residence and education separately showed a smaller prevalence of low cognitive function in persons with high social support availability compared to persons with low social support availability.	

[10] Oremus et al. (2020)	Social support availability is positively associated with memory in persons aged 45–85 years: A cross-sectional analysis of the Canadian Longitudinal Study on Aging	Cross-sectional	21,241 individuals aged 45-85 (Tracking Cohort) of the Canadian Longitudinal Study on Aging (CLSA)	Memory: Rey Auditory Verbal Learning Test Social support availability: Medical Outcomes Study-Social Support Survey (MOS-SSS)	Higher social support availability (four subscales and overall) was associated with better memory. Age group did not modify any of the associations between SSA and memory but was an independent and statistically significant predictor of memory. Both immediate and delayed recall were most associated with overall SSA and emotional/informational support.	Age, sex, education, province, marital status, home ownership, living arrangement, household income, rural/urban residence, smoking status, average alcohol consumption, ADL, IADL, chronic health conditions
[11] Pillemer et al. (2019)	Gender-stratified analyses reveal longitudinal associations between social support and cognitive decline in older men	Longitudinal 4 years	493 community-residing non-demented older adults (65+) in New York participating in Central Control of Mobility in Aging (CCMA) (mean age = 76.58)	Social support: Medical Outcomes Study – Social Support Survey (MOS-SSS) Incident cognitive impairment: Repeatable battery for the Assessment of Neuropsychological Status (RBANS)	Higher perceived support, overall and in specific domains, at baseline was associated with increased risk of incident cognitive impairment. Gender-stratified analyses revealed that higher perceived support at baseline was associated with increased risk of incident cognitive impairment only among males.	Education, gender, ethnicity, depressive symptoms, disease comorbidity, chronic or acute medical conditions
[12] Pillemer et al. (2016)	The differential relationships of dimensions of perceived social support with cognitive function among older adults	Cross-sectional	355 community-residing older adults (65+), living in New York, US, enrolled in a longitudinal cohort entitled Central Control of Mobility in Aging	Perceived SS: MOS-SSS Emotional & informational, positive social interaction, tangible support, affectionate support Cognition: Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)	Emotional & informational support and positive social interaction were significantly associated with RBANS total index score. Tangible support and affectionate support were not related to cognitive function. This may be attributed to the low levels of cognitive engagement that are required in these two dimensions of support. Gender moderated the relationship between emotional support and cognition (for female, higher level of perceived emotional support was associated with higher index score).	Age, gender, education, depression, comorbidities (chronic or acute)

[13] Sims et al. (2014)	Distinct functions of social support and cognitive function among older adults	Cross-sectional	175 healthy, community-dwelling individuals (54-83) in Baltimore, US (mean age = 66.32)	Social support: Interpersonal Support Evaluation List (ISEL) Cognitive function: executive function, visuospatial ability, visuo-constructional ability, nonverbal memory, perceptuo-motor speed, attention and working memory, verbal memory	No significant positive relations were found between social support and cognitive function in any domain. On the contrary, several functions of social support showed significant inverse relations with cognitive function, such that greater perceived social support was associated with poorer performance. For some individuals, i.e., those with a chronic illness or disability, receipt of social support may be perceived as a burden or stressor It is possible that social support may operate to negatively influence cognitive domains that are fluid in nature. Crystallized abilities are often enhanced in social environments such as school and work. Enhancement of fluid abilities does not typically rely on social interactions: they may be slowed by the distraction of social interactions.	Age, education, depressive symptoms, BP, BMI, diabetes, cholesterol
[14] Stoykova et al (2011)	Impact of social network on cognitive performance and age-related cognitive decline across a 20-year follow-up	Longitudinal 20 years	2,055 community-dwelling individuals (65+) in PAQUID study in France (Gironde, Dordogne)	Social functioning (size of social network, satisfaction with relationships, perception of being understood, and participation in social activities) Cognitive decline: MMSE (global cognition), The Similarities Test (abstract thinking), WPAT (episodic memory and learning), BVRT (immediate visual memory), DSST (visual-perceptual speed), IST (semantic verbal fluency).	Better social functioning at baseline is associated with better initial cognitive performance. There was no significant association with further cognitive decline. Even though higher social functioning is concomitantly associated with better cognitive performance, it may not prevent subsequent decline. People having a richer social network presented higher baseline performances in language and memory tests; however, their performances declined to the same extent as that of participants with poorer social networks.	Sex, education, marital status, IADL, depression, chronic diseases, cardiovascular diseases, sequelae of stroke

[15] Wilson et al. (2015)	Negative Social Interactions and Risk of Mild Cognitive Impairment in Old Age	Longitudinal 4.8 years	529 individuals (50+) in Rush Memory and Aging Project in Chicago (1997), followed up every year	Clinical evaluation: 5 cognitive domains (orientation, attention, memory, language, and perception) Cognitive function: Episodic memory (immediate and delayed recall), semantic memory, working memory, perceptual speed, visuospatial ability Negative social interactions: Psychometry scale	Frequent negative social interactions may be a risk factor for mild cognitive impairment and cognitive decline in old age. There was an interaction between age and negative social interaction score, such that the association of negative social interaction with risk of developing MCI was stronger among older participants than younger ones. Negative social interactions were related to non-amnestic MCI, but not amnestic MCI. Higher baseline negative social interaction score was associated with lower levels of working memory and visuospatial ability at baseline but not with decline in any domain. By contrast, higher mean negative social interaction score was associated with lower level of function in all domains and more rapid decline in episodic, semantic, and working memory.	Social network size, social activity, loneliness, depressive symptoms, stress coping skills, negative life events, age, sex, education
[16] Yilmaz et al. (2015)	Does social support affect development of cognitive dysfunction in individuals with diabetes mellitus?	Cross-sectional	121 patients with diabetes mellitus presenting at a hospital in Turkey	Perceived social support: Multidimensional Scale of Perceived Social Support (MSPSS) Cognitive dysfunction: standardized Mini Mental State Examination (SMMSE)	There was a significant positive correlation between cognitive function and social support. Individuals with cognitive dysfunction had low levels of perceived social support. Insufficient support from families and significant others contributed to the development of cognitive dysfunction.	

[17] Zahodne et al. (2018)	Positive psychosocial factors and cognition in ethnically diverse older adults	Cross-sectional	548 individuals (65+) in the Washington Heights-Inwood Columbia Aging Project (community-based, longitudinal study of aging and dementia in northern Manhattan)	Cognition: episodic memory (Selective Reminding Test), language (naming, letter and category fluency, verbal abstract reasoning, repetition, comprehension), visuospatial function (Benton Visual Retention Test, Rosen Drawing Test, Identities and Oddities subtest of the Dementia Rating Scale) Psychosocial factors (self-efficacy, social relationships, well-being)	There were no significant differences in the associations between any positive psychosocial factors and cognition across blacks and whites. The association between friendship and working memory was positive in whites but nonsignificant in Hispanics. The association between emotional support and working memory was negative in Hispanics, but nonsignificant in both whites and blacks. Higher self-efficacy was associated with better language ability across all ethnic groups. Purpose in life was negatively associated with working memory in Hispanics.	age, sex, years of education, language of test administration, depressive symptoms, health status
[18] Zhu et al. (2012)	Role of social support in cognitive function among elders	Cross-sectional	120 older adults (60+) were recruited via quasi-random sampling from Hubei Province, China	Social support: 12-item Multidimensional Scale of Perceived Social Support (MSPSS) from family, friends, and significant other Cognitive function: Mini Mental State Examination (MMSE)	There was a significant relationship between social support and cognitive function. Family support in particular had a significant positive effect on cognitive function. However, neither friend support nor significant other support was significantly correlated with cognitive function. Age was negatively associated with cognitive function.	Age, gender, education, chronic disease, marital status, residential arrangement, income

[19] Zuelsdorff et al. (2013)	Stressful events, social support, and cognitive function in middle-aged adults with a family History of Alzheimer's disease	Longitudinal 5 years	623 individuals middle-aged or older in Wisconsin-Madison, US, who have family history of AD and cognitively intact at baseline. WRAP (2001-2006)	RAVLT (immediate memory, verbal learning, and memory), Digits Forward, Digits Backward, and Letter-Number Sequence subtests of the Weschler Adult Intelligence Scale-III (working memory), Trails A, Trails B, and Stroop Color-Word (speed and flexibility) Stressful events Social support: MOS-SSS APOE genotyping	There was a positive relationship between perceived social support and speed and flexibility, but no association between support and memory. The hypothesis that life stress would be associated with poorer cognitive function, and that higher levels of perceived social support would be associated with better cognitive function, appear to be supported by cross-sectional data. On the other hand, the expected stress-support buffering effect, in the form of an interaction between the psychosocial factors, was not found.	demographic factors, medical and psychiatric history, physical activity, caregiving for a sick or limited friend or relative, use of tobacco, caffeine, and alcohol, height and weight

Literature on Functional + Structural Social Support and Cognitive Function

First author	Title	Study design	Study population	Measures	Conclusions & Findings	Covariates
[1] Amieva et al. (2010)	What aspects of social network are protective for dementia? Not the quantity but the quality of social interactions is protective up to 15 years later	Longitudinal 15 years	2,089 individuals (65+) in PAQUID cohort in France (Gironde and Dordogne)	Social network (marital status, size, composition), satisfaction in social networks, feelings of being either understood or misunderstood by most of your social network, relationship reciprocity. Dementia: diagnosis	Significant associations were found between satisfaction and reciprocity in relationships and the risk of dementia. Participants who felt satisfied with their relations had a 23% reduced dementia risk. Participants who reported that they received more support than they gave over their lifetime had a 55% and 53% reduced risk for dementia and Alzheimer's disease, respectively.	Sex, education, global cognitive status, IADL, chronic diseases, positive affect

[2] Chen et al. (2016)	Developmental patterns of cognitive function and associated factors among the elderly in Taiwan	Longitudinal 15 years	3,155 healthy older adults (65+) living in 56 townships in Taiwan and participating in Taiwan Longitudinal Study on Aging (TLSA) (1993-2007)	Social support: social interactions (playing games and socializing with others) and emotional support (being cared for when ill and being listened to by others) Cognitive function: short Portable Mental Status Questionnaire (SPMSQ)	A positive relationship was found between social support and cognitive function. An increase of emotional support by one point decreased the odds of being in the cognitively declining or in the low starting cognition group by 23%.	
[3] Conroy et al. (2010)	Boredom-proneness, loneliness, social engagement and depression and their association with cognitive function in older people: a population study	Cross-sectional	802 community-dwelling older individuals (65+) in Ireland (mean age = 74.2)	Social support: degree of availability of a person who made the participant feel loved/appreciated, a confidante, and a person who would provide practical help Loneliness: how often have you been bothered by loneliness in the past 12 months? Depression: Hospital Anxiety and Depression (HADS) – depression subscale Cognitive function: Abbreviated Mental Test (AMT)	The cluster of variables reflecting social support (low social support, being widowed, and currently living alone) were unrelated to cognitive function, which suggest that the reported associations between social support networks and cognitive function may reflect the protective role of social engagement rather than of social support.	Age, education

[4] de Leon et al. (2015)	Modeling active aging and explicit memory: An empirical study	Cross-sectional	184 healthy older adults in Madrid (mean age = 75.10)	Social resources: the Social Resources Scale (structural and functional social support as well as satisfaction with relationships) Explicit memory: Wechsler Memory Scale 3rd Edition Depression: GSD Perceived quality of life: The Philadelphia Scale of Satisfaction	Optimal social resources can improve explicit memory; improve the perception of quality of life, and decrease depression. Explicit memory is indirectly mediated by the availability of social resources.	
[5] Dickinson et al. (2011)	Change in stress and social support as predictors of cognitive decline in older adults with and without depression	Longitudinal 2 years	112 depressed adults (60+) from Neurocognitive Outcomes of Depression in the Elderly (NCODE) study and 101 non-depressed older adults from Center for Aging Subject Registry in the US	Depression: DDES, HRSD, MADRS, Clinical Global Impression scale Duke Social Support Index: instrumental social support, social interactions, subjective social support, and non-family social network Cognition: Immediate/delayed verbal memory (WMS-Revised), attention/ executive functions (TMT-A/B, SDMT, WAIS-Revised, Digit Span task) Stressful events: Life Events Scale	A decline in the total number of stressors was associated with a subsequent improvement on CERAD TS. In terms of social support, decreased social interaction and instrumental social support predicted decline in cognitive performance. These relationships were significant even after controlling for depression status, age, education, and sex. There was a consistent patterns of decreased social interaction and instrumental social support predicting decline in cognitive performance while controlling for depression status, age, education, and sex. Subjective social support and social network size did not appear to be associated with any changes in cognition.	Age, sex, education, physical health

[6] Frith et al. (2017)	Social support and cognitive function in older adults	Cross-sectional	1,874 individuals (60-85) in US from NHANES (1999-2002), excluding those with heart diseases	Cognitive function: DSST (digit symbol substitution test – visuospatial and motor speed of processing) Social support: can you count on anyone? Who was the most helpful with emotional support? How many close friends do you have?	Social support (relational fulfillment) of any degree was associated with improvement in cognitive ability. Sufficient spousal support and social network size resulted in higher performance of executive functions.	Age, gender, race, BMI, CRP, smoking status, diabetes, BP, physical activity
[7] Fuller-Iglesias et al. (2008)	Resilience in old age: Social relations as a protective factor	Cross-sectional	99 individuals (65+) participating in Social Relations and Health study who had 6+ negative life events in the past 12 years (Detroit, Michigan)	Adversity: negative life events scoring Social relations: network size and spousal quality Psychological well-being: depressive symptoms, life satisfaction	Both network size and spousal relationships proved to be important for facilitating resilience under challenging circumstances. The presence of larger social networks suggests that more people offer more opportunities for protection against the negative impact of adversity. Similarly, spousal relationships, characterized by high positive and low negative quality, are beneficial to those coping with significant negative life events.	Age, gender, race
[8] Ge et al. (2017)	Social support, social strain, and cognitive function among community-dwelling US Chinese older adults	Cross-sectional	3,159 individuals (60+) in Population Study of Chinese Elderly in Chicago (PINE) study	Cognitive function: C-MMSE, episodic memory (immediate and delayed recall of East Boston Memory Test: EBMT), executive function (symbol digit modalities test: SDMT), working memory (Digit Span Backwards test). Social Support: HRS (Health and Retirement Study) scale Social Strain: HRS scale	Higher levels of social support and social strain had significant associations with higher levels of cognitive outcomes (i.e., global cognitive function, episodic memory, working memory, and executive function). However, findings related to sources of social support and social strain were mixed. Strain from spouse and support from friends were significantly associated with global cognitive function, episodic memory, and executive function. Strain from friends was significantly associated with executive function. Support or strain from family members had no significant associations with any of the cognitive outcomes, regardless of adjusting for covariates or not.	Age, gender, education, marital status, personal annual income, length of residence in the community, living arrangement, depression, medical conditions, physical function, acculturation

[9] Glymour et al. (2008)	Social ties and cognitive recovery after stroke: Does social integration promote cognitive resilience?	Longitudinal 6 months	272 individuals (45+), who were admitted to 8 Boston area hospitals and rehabilitation facilities and met National Institute of Neurologic Diseases and Stroke criteria for ischemic or nontraumatic hemorrhagic stroke.	Social ties (intimate, personal, organizational ties) Social support (Barrera's Inventory of Socially Supportive Behaviors) - 7 emotional support items and 5 instrumental support items Cognitive function: Mini Mental State Examination (MMSE), attention, immediate and delayed recall, fluency.	Stroke survivors who reported social ties in multiple areas and those with higher emotional support immediately after stroke have better Cognitive Summary Scores 6 months later compared to socially isolated individuals or those with less emotional support. Higher levels of emotional support at baseline predicted better cognitive recovery during the follow-up period.	Age, sex, education, race, household income, comorbidity index
[10] Gow et al. (2013)	Which social network or support factors are associated with cognitive abilities in old age?	Cross-sectional	1,091 individuals (age 70) participating in Lothian Birth Cohort 1936 (Scotland)	Social support factors: marital status, living arrangement, social contact (volume), level of support received, satisfaction with social support Cognition: WAIS-III UK, Wechsler Memory Scale-III UK, tests of reaction time and inspection time	Participants who were unmarried or who lived alone performed more poorly on all the cognitive measures though the differences were significant only for marital status and general cognitive ability and processing speed. Receiving more social support was associated with better cognitive performance (there was no association with memory).	Social class (occupation), depressive symptoms (Hospital Depression and Anxiety Scale)
[11] Gow et al. (2016)	Social resources and cognitive ageing across 30 years	Longitudinal 30 years	802 individuals in the Glostrup 1914 Cohort (Copenhagen)	Social resources: marital status, living arrangements, frequency of telephone contact, loneliness, instrumental support (14 items), support to others (5 items) Cognitive ability: Wechsler Adult Intelligence Scale (11 tests)	Cognitive benefits were reported in terms of being married, not living alone, and reduced feelings of loneliness. Lack of association between social contact/support and cognitive ability. Interventions need to be more than simply increasing contact but may need to target the psychological underpinning of what makes older people experience loneliness.	Sex, education, social class

[12] Hoogendijk et al. (2016)	The Longitudinal Study Amsterdam (LASA): cohort update 2016 and major findings	Longitudinal 4 years (2011-2015)	Older individuals (55-85) recruited from Zwolle, Oss, and Amsterdam in the Netherlands	Social functioning: personal network size, social support, loneliness, social participation Cognitive functioning: general cognitive function, fluid intelligence, crystallized intelligence, executive function, memory	Frequent emotional support was associated with reduced feelings of loneliness and subsequently to better cognitive functioning. Increased emotional support also directly enhanced cognitive performance and this association was strongest among adults aged 65 years or older. Reduced complexity in social network was associated with poorer cognitive performance, but not with the rate of decline in performance.	
[13] Jeong et al. (2019)	Correlations between forgetfulness and social participation: Community diagnosing indicators	Cross-sectional	338,659 individuals (65-106) from 105 municipalities in Japan that provided data to the 2013 Survey of Needs in Spheres of Daily Life in Japan	Social environment factors: social participation, social contact, social support (giving, receiving) Forgetfulness: MHLW questionnaire	Higher levels of social participation, social contact, and social support were associated with lower levels of forgetfulness, even after adjusting for age and regional variables. Those who participate socially are less likely to develop forgetfulness.	
[14] Kats et al. (2016)	Social support and cognition in a community-based cohort: the Atherosclerosis Risk in Communities (ARIC) study	Longitudinal 20 years	13,119 individuals (45-64) from four communities in the US and participating in the prospective ARIC study (1987-2013)	Social support: a short form of the Interpersonal Support Evaluation List (ISEL-SF) – perception of appraisal support, tangible assets, belonging support, self-esteem support; the Lubben Social Network Scale (LSNS) – size and availability of active social network of family, friends, and peers Cognitive assessments: Digit Symbol Substitution Test (DSST), Delayed Word Recall Test (DWRT), Word Fluency Test (WFT)	Higher level of social support was moderately associated with greater global cognitive functioning at mid-life but did not predict change in global cognitive function into older adulthood. The absence of longitudinal associations may be attributed to using only baseline measurement of social support and selective attribution of the cohort over time.	Age, sex, study centre, highest education level, cigarette smoking, alcohol consumption, prevalent hypertension, prevalent diabetes

[15] Kelly et al. (2017)	The impact of social activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: a systematic review	Systematic review	3 RCTs, 34 observational studies, 2 genetic studies	Subjective measures of social activities, social networks, social support, composite measures of social relationships (CMSR) Cognitive function: episodic memory, semantic memory, overall memory ability, working memory, verbal fluency, reasoning, attention, processing speed, visuospatial abilities, overall executive functioning, and global cognition	Social activity was associated with global cognition and overall executive functioning, working memory, visuospatial abilities and processing speed, but not episodic memory, verbal fluency, reasoning, or attention. Social networks was associated with global cognition, but not episodic memory, attention or processing speed. Social support was associated with global cognition and episodic memory but not attention or processing speed. CMSR was associated with episodic memory and verbal fluency but not global cognition. Functional social support is a better predictor of health outcomes than structural social support.	
[16] Kotwal, et al. (2016)	Social function and cognitive status: Results from a US nationally representative survey of older adults	Cross-sectional	3,310 community-dwelling adults (62-90) from the US National Social life, Health, and Aging Project (NSHAP)	Social relationships: network structure (size and density), social resources (perceived social support and strain), social engagement (community involvement and socializing) Cognition: survey adaptation of the Montreal Cognitive Assessment (orientation, executive function, visuospatial skills, memory, attention, language)	Individuals at risk for mild cognitive impairment and dementia had smaller network sizes, an increase in network density, and less social strain. Among those at risk, only women had less perceived social support.	Self-reported age, gender, ethnicity, education, marital status, health status, depressive symptoms, tobacco use, exercise, alcohol consumption

[17] Krueger et al. (2009)	Social Engagement and Cognitive Function in Old Age	Cross-sectional	838 individuals from Rush Memory and Aging Project (recruited from subsidized housing facilities and continuous care retirement communities in Chicago)	Social engagement: social network size, frequency of participation in social activities, and perceived level of social support Cognition: composite measures of episodic memory, semantic memory, working memory, processing speed, and visuospatial ability	More frequent participation in social activities and a higher level of perceived social support were associated with higher level of cognitive functioning. Social network size was not related to cognitive function in this cohort. Adjustment for depression and personality and for cognitive and physical activities reduced the association by approximately 25%. This suggests that affect and activity lifestyle may partially account for the relation of perceived social support to cognition.	Depressive symptoms, personality traits (extraversion, neuroticism), participation in cognitively stimulating activities, frequency of physical activity, chronic conditions, disability, age, sex, education
[18] Kuiper et al. (2016)	Social relationships and cognitive decline: a systematic review and meta-analysis of longitudinal cohort studies	Systematic review	43 articles (31 on structural social support, 12 on functional social support, 8 on combination of structural and functional social support)	Structural social support: social network size, social activity Functional social support: social support, loneliness, satisfaction with household members A combination of structural and functional social support: composite scores	All associations between social relationships and cognitive decline were in the same direction (i.e. poor social relationships are associated with a higher risk of cognitive decline). However, as the operationalization of the social aspects varied (i.e. dimensional, categorical), no firm conclusions can be drawn about the strength of the association and thus the relative importance of the different social relationship aspects.	
[19] La Fleur et al. (2017)	Which aspects of social support are associated with which cognitive abilities for which people?	Cross-sectional	2,613 individuals (18-99) in Virginia, US	11 aspects of social support (social contact, received support, provided support, perceived support), 5 cognitive abilities (vocabulary, reasoning, spatial visualization, memory, speed of processing), general intelligence	Specific aspects of social support have different patterns of relations with cognition and their relations are primarily with global cognition. Emotional and informational received support positively predicted cognition. Tangible support was unrelated to cognitive abilities (less nurturing and more controlling than emotional support). Age, sex, health did not impact SS-cognition relation.	Sex, age, education

[20] Li et al. (2018)	Is social network a protective factor for cognitive impairment in US Chinese older adults? Findings from the PINE study	Cross-sectional	3,157 American Chinese older adults (60+) living in Chicago	Social network: network size, volume of contact, proportion kin, proportion female, proportion co-resident, and emotional closeness Cognitive function: global cognition, episodic memory, working memory, executive function, Chinese-MMSE	Unit increases in network size, volume of contact, proportion kin, proportion co-resident were associated with higher level of global cognition. Similar trends were observed in episodic memory, working memory, executive function and C-MMSE. Social network has differential impact on female versus male older adults	
[21] Liao et al. (2016)	Association of social support and cognitive aging modified by sex and relationship type: a prospective investigation in the English Longitudinal Study of Ageing	Longitudinal 8 years	10,241 individuals (50+) in the UK (excluding those diagnosed with Alzheimer's , Parkinson's, dementia, and severe memory impairment)	Social support: between-person differences, within-person changes, positive social support, negative social support, four relationship types (spouse, children, friends, extended family) Executive function: Verbal fluency, letter-cancellation tasks Memory: Time orientation, verbal learning, prospective memory	Higher positive social support was associated with better cognitive function and slower memory decline. Higher-than-usual (within-person) positive social support was associated with slower decline in memory. For men, higher positive social support from spouse and lower negative social support from all relationships were associated with higher cognitive function and slower cognitive decline. For women, positive SS from children and friends (but not from spouse) were associated with cognitive function. (Gender was a moderator.)	Sex, age, SES (education, wealth), health (mobility, depressive symptoms)

[22] Marioni et al. (2015)	Social activity, cognitive decline and dementia risk: A 20-year prospective cohort study	Longitudinal 20 years	2,854 individuals (65+) from the PAQUID cohort in France	Late-life engagement and self-perception of social relationships: social, intellectual, and physical engagement; size of social network; satisfaction with social relationships; and self-perception of feeling well understood Cognitive ability: Global cognition, verbal fluency, abstract thinking, episodic memory & learning, processing speed, immediate visual memory Incident dementia: DSM3	There was an associations between increased engagement in social, physical, or intellectual pursuits and increased cognitive ability (but not decline) and decreased risk of incident dementia, and between feeling understood and slower cognitive decline.	Instrumental Activities of Daily Living (IADL), depression, sequelae of stroke, ischemic heart disease (IHD), diabetes, sex, marital status, education
[23] Noguchi et al. (2019)	The association between social support sources and cognitive function among community-dwelling older adults: A one-year prospective study	Longitudinal 1 year	121 older adults (65+) recruited at health checkups in suburban towns in Japan (mean age = 73.86)	Social support: Two-Way Social Support Scale measuring emotional support and instrumental support (both receiving and providing) from three sources (co-residing family, non-coresiding family, and neighbors/friends) Cognitive function: Japanese version of the Montreal Cognitive Assessment (MoCA-J) – memory, visuospatial abilities, executive function, attention, concentration, working memory, language, time/space orientations	Social support exchanges with neighbors and friends were positively associated with cognitive function at one-year follow-up. Particularly, provision of emotional support to neighbors and friends had a significant impact on the maintenance of cognitive function, after adjusting for all covariates.	Age, sex, BMI, living alone, equivalent income, medical history, depression, IADL, walking speed, walking time

[24] Penninkilampi et al. (2018)	The association between social engagement, loneliness, and risk of dementia: a Systematic review and meta-analysis	Systematic review	31 studies (cohort and case-control) examining the association between social engagement or loneliness and dementia risk.		Poor social engagement indices were associated with increased dementia risk, including having a poor social network and poor social support. In long-term studies, good social engagement was modestly protective.	
[25] Poey et al. (2017)	Social connectedness, perceived isolation, and dementia: Does the social environment moderate the relationship between genetic risk and cognitive well-being?	Cross-sectional	779 individuals (70+) in the Aging, Demographics, and Memory Study (ADAMS) module of the Health and Retirement Study (HRS) in the US	Family network size, social engagement (volunteering, giving help, paid work), perceived social support availability, loneliness (CES-D8) APE e4 allele Cognitive diagnosis	Living alone and self-reported loneliness were associated with a greater risk of cognitive difficulty. A richer social environment is associated with less risk of cognitive decline and presence of the APOE e4 allele was related to poorer cognitive health. The e4 allele and being less socially engaged were independently associated with a greater risk of Alzheimer's disease. Living arrangements, perceived social support, and loneliness were found to moderate the relationship between APOE e4 allele and cognitive function.	Cognitive status, sex, depressive symptoms

[26] Seeman et al. (2001)	Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur Studies of Successful Aging	Longitudinal 7.5 years	1,189 relatively high-functioning adults (70-79) in three regions in US (MacArthur Studies of Successful Aging: 1989-1996)	Cognitive function (6 domains): language (Boston Naming Test), abstraction (Wechsler Adult Intelligence Scale-revised), spatial ability, delayed spatial recognition, incidental recall of confrontation naming items, delayed recall of a story. Quantitative social support: Marital status, number of close ties with children, number of close friends and relatives, participation in religious or other groups. Qualitative social support: Frequency of receiving emotional and instrumental support, frequency of negative interactions, frequency of providing support to others	At baseline, greater emotional support was associated with better cognitive function. Better cognitive function was correlated with being unmarried and reporting greater conflicts/demands from social network (but unmarried participants were more women than men). Longitudinally, baseline emotional support was a significant, independent predictor of maintenance of better cognitive function over 7.5 years, independent of depressive symptoms and self-efficacy beliefs. For men and women, social ties and support demonstrated generally similar patterns of association. Big difference was in marital status – for men, being married was associated with larger network size and greater emotional/instrumental support. For women, being married was associated with fewer other close ties, less group memberships, and less emotional support. No evidence for any mediational effects of covariates.	Age, education, ethnicity, income, number of chronic conditions, pulmonary function, depressive symptoms, self-efficacy beliefs, frequency of leisure and work related activity, frequency of strenuous activities conducted on a regular basis

[27] Seeman et al. (2011)	Histories of social engagement and adult cognition: Midlife in the US Study	Longitudinal 9.5 years	7,108 adults (25-74) (1994/5 – 2005/6) in the Midlife in the US (MIDUS) study – not equally distributed across SES	Cognitive function: BTACT (brief test of adult cognition by telephone) – six domains: episodic memory (immediate and delayed word list recall), working memory (digits backward), executive function & semantic memory (category fluency), reasoning (number series completion), speed of processing (backward counting) Social engagement: Frequency of social contacts, extent of social support and social conflict	There was a significant positive association between social contacts and support and executive function and episodic memory, independent of all covariates. Social conflict was significantly and negatively associated with executive function but not episodic memory. Over time, decline in social contact was associated with poorer executive function and episodic memory. Social support-cognition association was stronger among younger than older adults (may be due to attrition and survivor bias)	Age, gender, education, race, health status, health behaviors
[28] Sorman et al. (2015)	Social relationships and risk of dementia: a population-based study	Longitudinal 16 years	1,715 dementia-free older adults (65+) in Umea, Sweden (mean age = 74.20, 74.51, 73.80 across the test occasions)	Social relationships: questionnaire and interview by nurses (living status, presence of a close friend, frequency of contact with friends, perceived frequency of social contact) Diagnosis of dementia: DSM-4 and MMSE	A higher value on the relationship index was associated with reduced risk of all-cause dementia and Alzheimer's disease before and after controlling for all covariates. Once a week or more frequent visits from friends and acquaintances was related to a lower risk of all-cause dementia.	Age, gender, years of education, global cognition, alcohol use, smoking status, obesity, a sum of self-reported diseases, perceived general stress, depressive symptoms index,

[29] Wang et al. (2017)	Association of social support and family environment with cognitive function in peritoneal dialysis patients	Cross-sectional	173 patients (18+) of peritoneal dialysis in Peking University First Hospital in China (mean age = 55.5)	Social support: 10-item social support Rating Scale developed by Xiaoshuiyuan (divided into subjective support, objective support, and support utilization) Family environment: Chinese version of Family Environment Scale (FES-CV) Cognitive function: modified Mini Mental State Examination (3MS), Trail Making Test A/B, Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)	Higher global social support was associated with a higher risk of cognitive impairment after adjusting for the covariates. Global social support, objective support, subjective support, support utilization were not significantly associated with specific cognitive test scores. Greater independence was significantly associated with higher scores on specific cognitive tests, i.e. immediate and delayed memory.	Age, gender, education, BMI, diabetes, cardiovascular disease, serum albumin, hs-CRP, total Kt/V
[30] Yeh et al. (2003)	Influence of social support on cognitive function in the elderly	Cross-sectional	4,989 community-dwelling individuals (65+) in Kaohsiung, Taiwan	Cognition: Short Portable Mental Status Questionnaire Social support: marital status, perceive support, living alone, loneliness	Marital status and perceived support were significantly associated with cognition. Living alone and loneliness were not significantly associated with the cognition scores. Loneliness did not have a statistically significant influence on cognitive function.	Age, sex, education, religion, occupation, physical health, IADL, ADL, reported health condition

[31] Zahodne et al. (2019)	Social relations and age-related change in memory	Longitudinal 6 years	10,390 individuals (50+) participating in the Health and Retirement Study (HRS) (mean age = 69) followed up every 2/4 years	Structural dimensions of social relations: marital status, network size, frequency of social contact Quality of social relations: social support and strain from social network members Episodic memory: a variant of the Consortium to Establish a Registry for Alzheimer's disease (CERAD) list learning task	Associations between quality of social relations and cognitive health were not evident over time. The lack of a prospective association between social strain and subsequent memory change may reflect the relatively young age of the sample and short follow-up.	Age, gender, self-reported race and ethnicity, education, mental and physical health, chronic conditions, self-rated health
[32] Zhou et al. (2018)	Social engagement and its change are associated with dementia risk among Chinese older adults: a longitudinal study	Longitudinal 9 years	7511 adults (65+) in Hubei province of China (Chinese Longitudinal Healthy Longevity Study, CLHLS, 2002-2012)	Social engagement: marital status, living arrangement, availability of help when required, availability of confidant, participation in social activities Change in social engagement: consistently low, decreasing, increasing, consistently medium, consistently high. Dementia: diagnosis	Social engagement was significantly associated with the risk of dementia. People whose social engagement remained high/medium had a significantly lower risk of dementia than those whose social engagement remained low. Increasing social engagement was associated with lower risk of dementia than consistently low social engagement. Consistently high social engagement did not lead to a lower risk of dementia compared to consistently medium social engagement.	Age, literacy, type of residence, engagement in physical labor, smoking, drinking, exercise, cognitive functioning (MMSE)

[33] Zuelsdorff et al. (2019)	Social support and verbal interaction are differentially associated with cognitive function in midlife and older age	Cross-sectional	1,052 cognitively healthy individuals (40+) participating in Wisconsin Registry for Alzheimer's Prevention (WRAP) (mean age = 60.2)	Social engagement: self-reported perceived social support (Medical Outcomes Study – Social Support Survey) and quantity of weekly verbal interactions. Cognitive function: episodic memory (Rey Auditory Verbal Learning Test, Brief Visuospatial Memory Test – Revised, Wechsler Memory Scale - Revised) and executive function (Trail Making Test A/B, Stroop Neuropsychological Screening Test Color-Word Interference condition, Digit Span Forward/backward, Wechsler Adult Intelligence Scale-III)	There was a positive relationship between social engagement and speed& flexibility and immediate memory scores, when adjusted for all covariates. The relationship between quantity of verbal interaction and cognitive test performance was parabolic rather than linear in shape.	Smoking status, alcohol use, caffeine consumption, BMI, self-reported physical activity, partner status

Appendix B. Provincial and Overall Response Rates for the CLSA Comprehensive Cohort

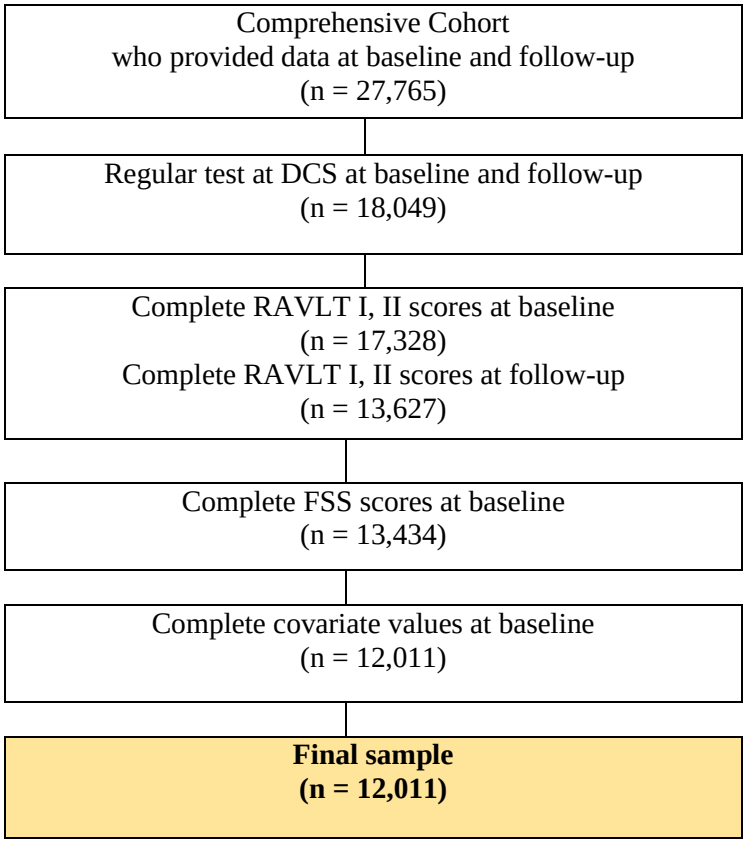
Table B. Provincial and Overall Response Rates for the CLSA Comprehensive Cohort[160]

	AB	BC	MB	NL	NS	ON	QC	Canada
TS	0.11	0.10	0.10	0.15	0.12	0.09	0.10	0.10
RDD	0.11	0.10	0.13	0.19	0.16	0.10	0.12	0.11
RTS	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02
HR	-	0.02	0.09	0.06	0.14	0.09	-	0.09
HR1	-	0.02	0.09	0.06	0.16	0.09	-	0.09
HR2	-	-	-	-	0.08	-	-	0.08
Overall	**0.11**	**0.09**	**0.10**	**0.12**	**0.13**	**0.09**	**0.10**	**0.10**

TS: Telephone Sampling
RDD: Random Digit Dialing
RTS: Random (Telephone) Sampling from listed telephone numbers
HR: Provincial Health Registry mail-outs
HR1: Initial Health Registry mail-outs
HR2: Health Registry mail-outs targeting lower-educated areas

Appendix C. Extraction of Analytical Sample

Figure C. Extraction of Analytical Sample



Appendix D. List of Words Used in the Rey Auditory Verbal Learning Test (RAVLT)

Table D. List of Words Used in the Rey Auditory Verbal Learning Test (RAVLT) [73]

ENGLISH	FRENCH
Drum	Tambour
Curtain	Rideau
Bell	Cloche
Coffee	Café
School	École
Parent	Parent
Moon	Lune
Garden	Jardin
Hat	Chapeau
Farmer	Fermier
Nose	Nez
Turkey	Dinde
Color	Couleur
House	Maison
River	Riviere

Appendix E. Medical Outcomes Study – Social Support Survey (MOS–SSS)

Table E. Medical Outcomes Study – Social Support Survey (MOS–SSS)[101]

Item	Questions	Type of Functional Social Support
3	Someone you can count on to listen to you when you need to talk	Emotional/Informational
4	Someone to give you advice about a crisis	
8	Someone to give you information in order to help you understand a situation	
9	Someone to confide in or talk to about yourself or your problems	
13	Someone whose advice you really want	
16	Someone to share your most private worries and fears with	
17	Someone to turn to for suggestions about how to deal with a personal problem	
19	Someone who understands your problems	
2	Someone to help you if you were confined to bed	Tangible
5	Someone to take you to the doctor if you needed it	
12	Someone to prepare your meals if you were unable to	
15	Someone to help you with daily chores if you were sick	
6	Someone who shows you love and affection	Affectionate
10	Someone who hugs you	
20	Someone to love you and make you feel wanted	
11	Someone to get together with for relaxation	Positive social interaction
18	Someone to do something enjoyable with	
7	Someone to have a good time with	
14	Someone to do things with to help you get your mind off things	Additional item

This table was adapted from the original MOS-SSS (Sherbourne et al., 1991), which contains total 20 items. Item 1 (About how many close friends and close relatives do you have (people you feel at ease with and can talk to about what is on your mind)?) was excluded in this study because it assesses structural support. Item 14 was not grouped into any subtypes, but included into overall FSS as per the literature on factor analysis.[219]

Appendix F. Measurement of Covariates

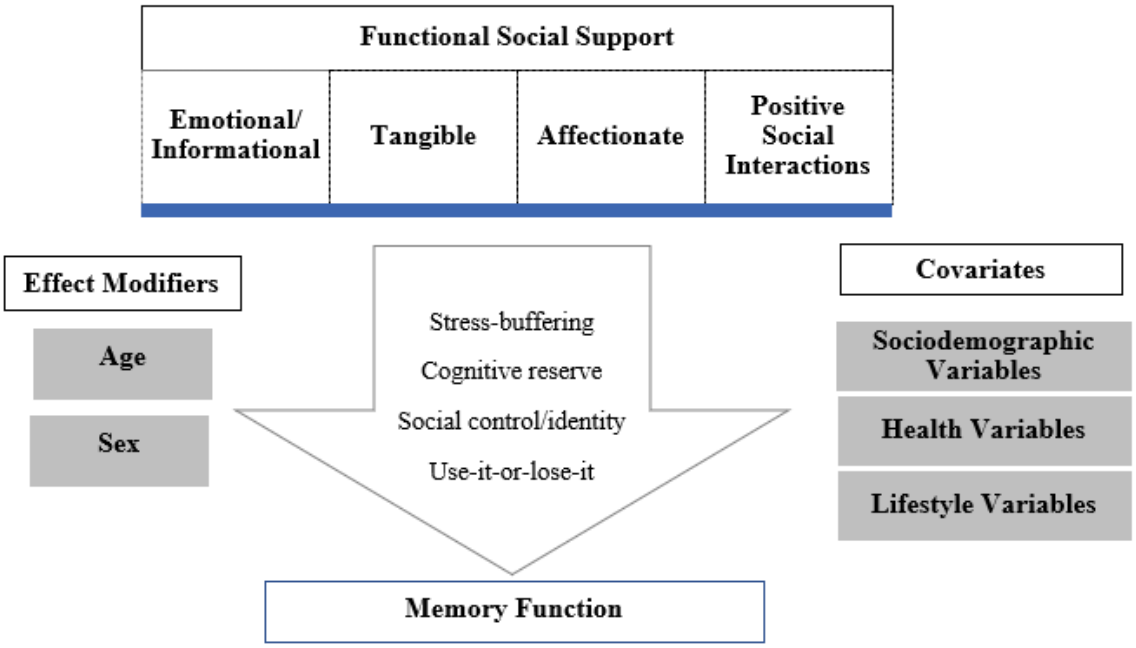
Table F. Measurement of Covariates

	Covariate	Measurement	Scale
Socio-demographic	Sex	Male Female	
	Age	45-54 years 55-64 years 65-74 years 75 years or older	
	Education	Less than high school High school diploma Some post-secondary education Post-secondary degree/diploma	
	Province of residence	One of the seven provinces	
	Total annual household income	Less than $20,000 From $20,000 to under $50,000 From $50,000 to under $100,000 From $100,000 to under $150,000 $150,000 or more	
	Marital status	0 (single, widowed, divorced, separated, never married) 1 (married, common-law partnership)	
	Living arrangement	0 (living alone) 1 (living with someone)	
Health	Functional status	0 (no assistance required for any activity) 1 (assistance required for at least one activity)	Modified OARS[1]
	Chronic conditions	0 (no chronic condition) 1 (one chronic conditions) 2 (two chronic conditions) ≥3 (three or more chronic conditions)	
	Depressive symptoms	Score between 1 and 30	CES-D10[2]
Lifestyle	Smoking status	0 (never smoker) 1 (former smoker) 2 (current smoker)	Modified CHMS[3] and CTUMS[4]
	Alcohol use	0 (never drinker) 1 (former drinker) 2 (current drinker)	Modified CAMHM[5]

[1] Older Americans Resources and Services – Multidimensional Assessment Questionnaire
[2] Center for Epidemiologic Studies Short Depression Scale
[3] Canadian Health Measures Survey
[4] Canadian Tobacco Use Monitoring Survey
[5] Centre for Addiction and Mental Health Monitor

Appendix G. Conceptual Diagram of the Association between Functional Social Support and Memory

Figure G. Conceptual Diagram of the Association between Functional Social Support and Memory



Sociodemographic Covariates	Age, sex, education, province of residence, annual household income, marital status, living arrangement
Health Covariates	Chronic conditions, Functional status, Depressive symptoms
Lifestyle Covariates	Smoking status, alcohol use

Appendix H. Descriptive Statistics of the CLSA Comprehensive Cohort

Table H-1. Sociodemographic, Health, and Lifestyle Characteristics of the Comprehensive Cohort (n = 30,097)

Characteristics	Unweighted n = 30,097		Weighted n = 3,746,316	
	n	%	n	%
Sex				
Male	14,777	49.10	1,859,583	49.64
Female	15,320	50.90	1,886,733	50.36
Age Group				
45-54 years	7,595	25.24	1,572,256	41.97
55-64 years	9,856	32.75	1,114,799	29.76
65-74 years	7,362	24.46	642,993	17.16
75 years and older	5,284	17.56	416,268	11.11
Province				
Alberta	2,957	9.82	449,805	12.01
British Columbia	6,254	20.78	1,116,157	29.79
Manitoba	3,113	10.34	308,654	8.24
Newfoundland & Labrador	2,214	7.36	80,983	2.16
Nova Scotia	3,078	10.23	130,223	3.48
Ontario	6,418	21.32	488,770	13.05
Quebec	6,063	20.14	1,171,724	31.28
Education				
Less than high school	1,643	5.47	181,519	4.85
High school diploma	2,839	9.45	335,075	8.96
Some post-secondary	2,238	7.45	250,936	6.71
Post-secondary diploma	23,327	77.64	2,973,337	79.48
Annual Household Income				
≤ $19,999	1,566	5.56	165,767	4.69
$ 20,000 – 49,999	6,360	22.59	662,799	18.74
$ 50,000 – 99,999	9,907	35.19	1,177,394	33.29
$ 100,000 – 149,999	5,524	19.62	784,321	22.18
≥ $ 150,000	4,799	17.04	746,275	21.10
Marital Status				
Married or common-law relationship	20,651	68.61	2,841,504	75.85
Single, widowed, divorced, separated	9,446	31.39	904,812	24.15
Living Arrangement				
Alone	6,822	22.67	589,287	24.15
With others	23,275	77.33	3,157,029	75.85
Number of Chronic Conditions				
None	9,387	32.52	1,365,167	37.77
1	9,021	31.25	1,147,103	31.74
2	5,713	19.79	631,811	17.48
3 or more	4,744	16.44	470,314	13.01
Functional Status				
No functional impairment	27,058	90.23	3,430,582	91.95
Mild impairment	2,560	8.54	263,148	7.05
Moderate impairment	284	0.95	27,783	0.74
Severe impairment	65	0.22	7,266	0.19
Total impairment	22	0.07	2,292	0.06
Depressive Symptoms	Median	25^{th} /75^{th}	Median	25^{th}/75^{th}
	4.00	2.00/ 7.00	3.71	1.44/ 6.95

Table H-1 (Cont'd). Sociodemographic, Health, and Lifestyle Characteristics of the Comprehensive Cohort (n = 30,097)

Characteristics	Unweighted Sample n = 30,097		Weighted Sample n = 3,746,316	
	n	%	n	%
Smoking Status				
Never smoker	14,265	47.52	1,857,824	49.70
Former smoker	13,186	43.93	1,542,454	41.26
Current smoker	2,567	8.55	337,841	9.04
Alcohol Use				
No drinker	3,427	11.67	405,986	11.08
Occasional drinker	3,705	12.61	418,003	11.41
Regular drinker	22,239	75.72	2,840,042	77.51

Table H-2. Comparison of the Characteristics between Baseline and Follow-up (n-30,097)

Variable	Baseline (Weighted) n = 3,746,316		Follow-up (Weighted) n = 3,746,316	
	n	%	n	%
Annual Household Income				
≤ $19,999	165,767	4.69	134,203	4.05
$ 20,000 – 49,999	662,799	18.74	598,085	18.04
$ 50,000 – 99,999	1,177,394	33.29	1,122,150	33.85
$ 100,000 – 149,999	784,321	22.18	725,157	21.87
≥ $ 150,000	746,275	21.10	735,948	22.20
Marital Status				
Married or common-law relationship	2,841,504	75.85	2,446,935	65.32
Single, widowed, divorced, separated	904,812	24.15	1,299,381	34.68
Living Arrangement				
Alone	589,287	24.15	601,532	16.06
With others	3,157,029	75.85	3,144,784	83.94
Number of Chronic Conditions				
None	1,365,167	37.77	1,124,188	33.93
1	1,147,103	31.74	1,036,387	31.28
2	631,811	17.48	629,434	19.00
3 or more	470,314	13.01	523,574	15.80
Functional Status				
No impairment	3,430,582	91.95	2,883,751	86.68
Mild impairment	263,148	7.05	368,647	11.08
Moderate impairment	27,783	0.74	54,884	1.65
Severe impairment	7,266	0.19	12,909	0.39
Total impairment	2,292	0.06	6,850	0.21
Depressive Symptoms	Median	IQR*	Median	IQR
	3.71	5.51	3.55	5.53
Smoking Status				
Never smoker	1,857,824	49.70	1,857,824	51.60
Former smoker	1,542,454	41.26	1,482,762	41.18
Current smoker	338,841	9.04	259,884	7.22

Table H-2 (Cont'd). Comparison of the Characteristics between Baseline and Follow-up (n = 30,097)

Variable	Baseline (Weighted) n = 3,746,316		Follow-up (Weighted) n = 3,746,316	
	n	%	n	%
Alcohol Use				
No drinker	405,986	11.08	391,349	11.18
Occasional drinker	418,003	11.41	391,832	11.20
Regular drinker	2,840,042	77.51	2,715,765	77.62

* IQR: inter-quartile range

Table H-3. FSS Scores of the Comprehensive Cohort at Baseline and Follow-up (n = 30,097)

FSS	Unweighted n=30,097		Weighted n=3,746,316	
	Baseline (Median, IQR*)	**Follow-up** (Median, IQR)	**Baseline** (Median, IQR)	**Follow-up** (Median, IQR)
Overall support	4.42 (1.00)	4.42 (0.95)	4.41 (0.92)	4.40 (0.97)
Emotional/Informational support	4.38 (1.13)	4.38 (1.00)	4.30 (1.05)	4.28 (1.08)
Affectionate support	4.67 (1.00)	5.00 (1.00)	4.69 (0.82)	4.67 (0.90)
Tangible support **	4.21 (1.25)	4.50 (1.00)	4.37 (1.03)	4.40 (0.95)
Positive social interactions	4.21 (1.25)	4.25 (1.25)	4.27 (1.06)	4.22 (1.11)

* IQR: inter-quartile range
* Wilcoxon Signed-Rank test (unweighted, random sample of 1,000 participants) p = 0.04

Table H-4. RAVLT I and II Z-Scores of the Comprehensive Cohort at Baseline and Follow-up (n = 30,097)

	Unweighted n = 30,097		Weighted n = 3,746,316	
	Baseline (Mean, 95% CI*)	**Follow-up** (Mean, 95% CI)	**Baseline** (Mean, 95% CI)	**Follow-up** (Mean, 95% CI)
RAVLT I	0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	0.12 (0.11, 0.14)	-0.00 (-0.02, 0.01)
RAVLT II	0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	0.13 (0.11, 0.14)	-0.01 (-0.02, 0.01)

* CI represents confidence interval

Appendix I. Diagnostics of the Fully Adjusted Regression Models for the Association between FSS and RAVLT Change

Figure I-1. Diagnostics of the Fully Adjusted Regression Model for the Association between Overall FSS and RAVLT Change

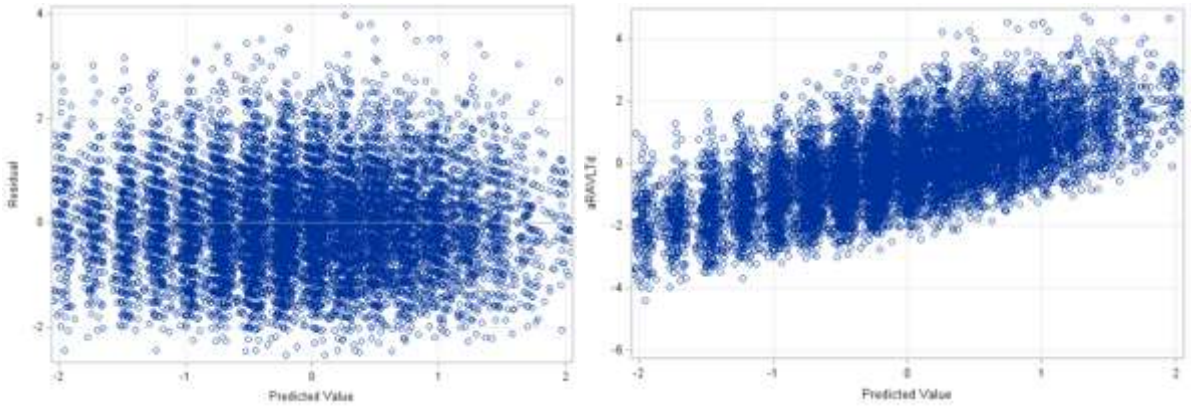


Figure I-2. Diagnostics of the Fully Adjusted Regression Model for the Association between Emotional/Informational Support and RAVLT Change

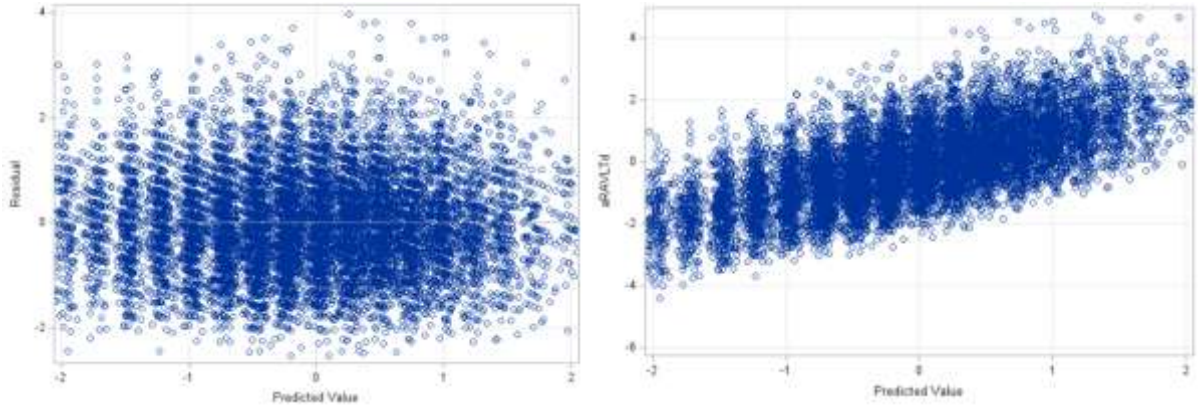


Figure I-3. Diagnostics of the Fully Adjusted Regression Model for the Association between Affectionate Support and RAVLT Change

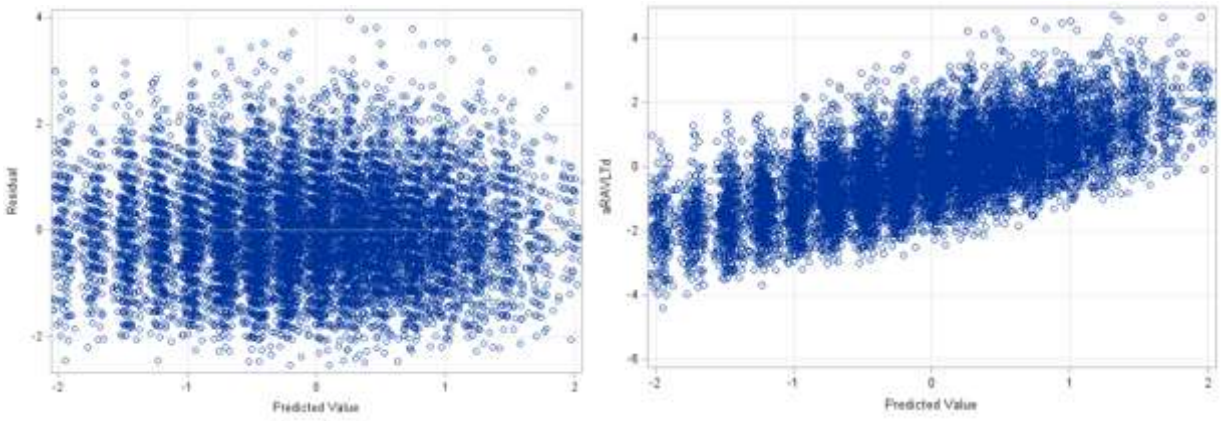


Figure I-4. Diagnostics of the Fully Adjusted Regression Model for the Association between Tangible Support and RAVLT Change

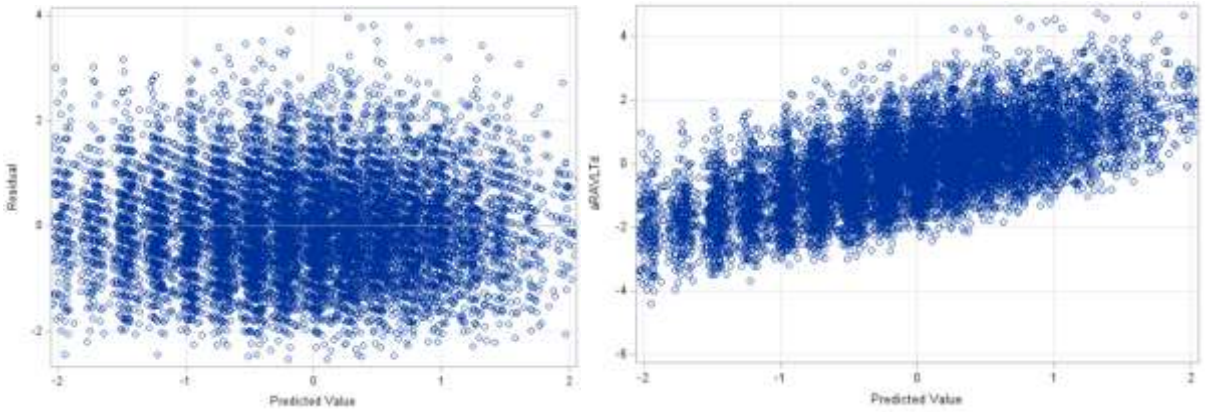
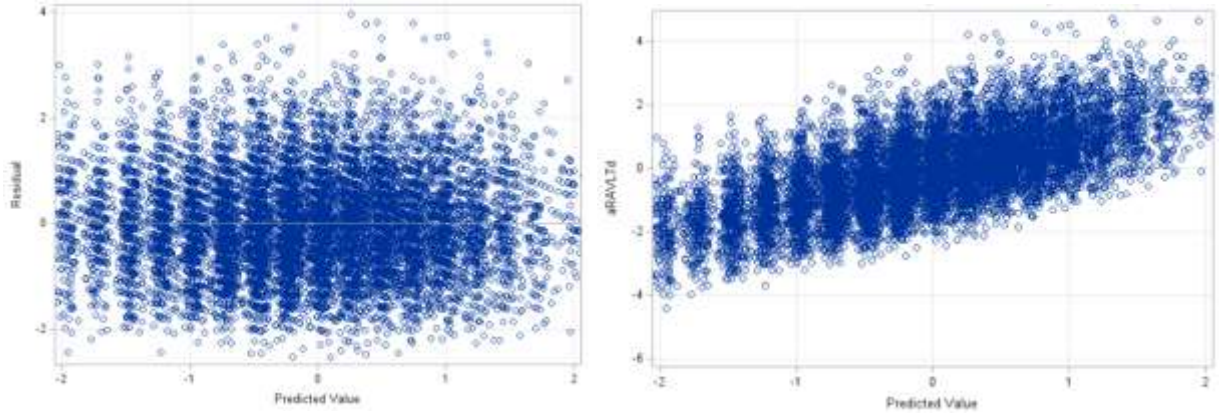


Figure I-5. Diagnostics of the Fully Adjusted Regression Model for the Association between Positive Social Interactions and RAVLT Change



Appendix J. Multiple Linear Regression of the Association between FSS and RAVLT Change Stratified by Age Group

Table J-1. Multiple Linear Regression of the Association between Overall FSS and RAVLT Change Stratified by Age Group

	Age			
	45-54 years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
R^2	0.4879	0.4890	0.4500	0.4237
Adjusted R^2	0.4867	0.4878	0.4487	0.4223
High Overall FSS (vs. low)	0.04 (-0.12, 0.20)	0.10 (-0.03, 0.22)	-0.07 (-0.24, 0.10)	-0.05 (-0.25, 0.15)
Baseline RAVLT	**-1.00 (-1.03, -0.96)**	**-1.04 (-1.07, -1.00)**	**-1.02 (-1.07, -0.97)**	**-1.02 (-1.09, -0.94)**
Sex (vs. male)				
Female	0.00 (-0.06, 0.07)	0.01 (-0.05, 0.07)	0.03 (-0.06, 0.11)	-0.05 (-0.19, 0.09)
Province (vs. Ontario)				
Alberta	0.06 (-0.06, 0.17)	**-0.13 (-0.24, -0.02)**	0.05 (-0.10, 0.20)	-0.06 (-0.28, 0.15)
British Columbia	-0.02 (-0.12, 0.08)	**-0.11 (-020, -0.02)**	0.05 (-0.06, 0.16)	-0.03 (-0.19, 0.13)
Manitoba	0.11 (-0.00, 0.23)	-0.04 (-0.16, 0.07)	-0.02 (-0.15, 0.12)	0.02 (-0.19, 0.23)
Newfoundland and Labrador	0.00 (-0.13, 0.13)	0.00 (-0.13, 0.13)	0.10 (-0.06, 0.26)	-0.13 (-0.36, 0.11)
Nova Scotia	0.05 (-0.08, 0.18)	-0.11 (-0.23, 0.01)	0.12 (-0.04, 0.29)	-0.18 (-0.42, 0.05)
Quebec	0.04 (-0.06, 0.14)	**-0.13 (-0.22, -0.04)**	0.03 (-0.08, 0.14)	-0.13 (-0.30, 0.04)
Education (vs. less than secondary)				
Secondary education	**0.38 (0.13, 0.63)**	0.14 (-0.05, 0.33)	**-0.19 (-0.37, -0.01)**	0.08 (-0.15, 0.31)
Some post-secondary education	**0.37 (0.12, 0.62)**	0.05 (-0.14, 0.25)	-0.07 (-0.27, 0.13)	-0.07 (-0.32, 0.17)
Post-secondary education	**0.32 (0.10, 0.53)**	0.10 (-0.07, 0.27)	-0.06 (-0.22, 0.09)	-0.06 (-0.25, 0.13)

Table J-1. (Cont'd) Multiple Linear Regression of the Association between Overall FSS and RAVLT Change Stratified by Age Group

	Age			
	45-54 years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)				
$20,000 - $49,999	-0.09 (-0.28, 0.19)	0.01 (-0.17, 0.18)	-0.03 (-0.21, 0.16)	-0.13 (-0.34, 0.07)
$50,000 - $99,999	-0.04 (-0.28, 0.19)	0.04 (-0.14, 0.21)	0.01 (-0.18, 0.20)	-0.17 (-0.38, 0.05)
$100,000 – $149,999	0.03 (-0.21, 0.280	-0.00 (-0.19, 0.18)	-0.02 (-0.23, 0.19)	-0.05 (-0.31, 0.21)
≥ $150,000	0.01 (-0.24, 0.26)	0.07 (-0.12, 0.26)	0.02 (-0.21, 0.24)	-0.00 (-0.30, 0.29)
Marital status (vs. married/common-law)				
Single, widowed, divorced, separated	-0.05 (-0.16, 0.05)	0.10 (-0.02, 0.22)	-0.04 (-0.20, 0.12)	0.11 (-0.11, 0.33)
Living arrangement (vs. living alone)				
Living with someone	-0.04 (-0.17, 0.08)	0.06 (-0.07, 0.18)	-0.01 (-0.18, 0.15)	0.13 (-0.08, 0.34)
Functional status (vs. no impairment)				
Mild impairment	-0.02 (-0.21, 0.18)	-0.00 (-0.14, 0.13)	0.04 (-0.11, 0.19)	-0.15 (-0.31, 0.01)
Moderate, severe, total impairment	**-0.65 (-1.01, -0.28)**	0.32 (-0.57, 1.21)	-0.08 (-0.68, 0.52)	-0.16 (-0.54, 0.23)
Chronic conditions (vs. no conditions)				
1 chronic condition	0.03 (-0.04, 0.10)	-0.03 (-0.10, 0.04)	0.01 (-0.08, 0.11)	-0.05 (-0.22, 0.12)
2 chronic conditions	0.02 (-0.08, 0.13)	-0.05 (-0.13, 0.04)	-0.06 (0.16, 0.05)	-0.08 (-0.25, 0.10)
≥ 3 chronic conditions	0.01 (-0.15, 0.17)	-0.02 (-0.12, 0.08)	0.06 (-0.05, 0.17)	-0.00 (-0.19, 0.18)
Depressive symptoms	-0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	-0.00 (-0.01, 0.01)	-0.00 (-0.02, 0.01)
Smoking status (vs. never smoker)				
Former smoker	**0.07 (0.00, 0.15)**	-0.03 (-0.10, 0.03)	0.01 (-0.06, 0.09)	-0.12 (-0.23, 0.00)
Current smoker	0.10 (-0.02, 0.21)	0.01 (-0.10, 0.13)	0.03 (-0.19, 0.24)	0.06 (-0.30, 0.42)
Alcohol use (vs. no alcohol use)				
Occasional use	0.08 (-0.07, 0.22)	0.11 (-0.02, 0.24)	-0.01 (-0.16, 0.15)	0.26 (0.05, 0.48)
Regular use	0.04 (-0.06, 0.14)	0.04 (-0.07, 0.14)	-0.04 (-0.15, 0.08)	0.12 (-0.03, 0.27)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Table J-2. Multiple Linear Regression of the Association between Emotional/Informational Support and RAVLT Change Stratified by Age Group

	Age			
	45-54years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
R^2	0.4880	0.4888	0.4499	0.4240
Adjusted R^2	0.4868	0.4876	0.4486	0.4227
High Emotional/Informational Support (vs. low)	0.08 (-0.07, 0.23)	-0.04 (-0.16, 0.07)	-0.00 (-0.13, 0.13)	0.08 (-0.09, 0.26)
Baseline RAVLT	**-1.00 (-1.03, -0.96)**	**-1.04 (-1.07, -1.00)**	**-1.02 (-1.07, -0.97)**	**-1.02 (-1.09, -0.94)**
Sex (vs. male)				
Female	0.00 (-0.06, 0.07)	0.01 (-0.05, 0.08)	0.03 (-0.06, 0.11)	-0.05 (-0.19, 0.09)
Province (vs. Ontario)				
Alberta	0.06 (-0.06, 0.17)	**-0.13 (-0.24, -0.02)**	0.05 (-0.10, 0.20)	-0.07 (-0.28, 0.15)
British Columbia	-0.02 (-0.12, 0.08)	**-0.11 (-0.20, -0.02)**	0.05 (-0.06, 0.16)	-0.03 (-0.19, 0.13)
Manitoba	0.11 (-0.00, 0.23)	-0.04 (-0.16, 0.08)	-0.02 (-0.15, 0.12)	0.02 (-0.19, 0.23)
Newfoundland and Labrador	-0.00 (-0.13, 0.13)	0.00 (-0.12, 0.13)	0.10 (-0.07, 0.26)	-0.13 (-0.36, 0.11)
Nova Scotia	0.05 (-0.08, 0.18)	-0.11 (-0.23, 0.02)	0.12 (-0.05, 0.29)	-0.19 (-0.42, 0.05)
Quebec	0.04 (-0.06, 0.14)	**-0.13 (-0.22, -0.03)**	0.03 (-0.08, 0.14)	-0.13 (-0.29, 0.04)
Education (vs. less than secondary)				
Secondary education	**0.38 (0.13, 0.62)**	0.15 (-0.04, 0.34)	**-0.19 (-0.37, -0.01)**	0.07 (-0.16, 0.30)
Some post-secondary education	**0.37 (0.12, 0.62)**	0.06 (-0.14, 0.25)	-0.07 (-0.27, 0.13)	-0.08 (-0.32, 0.17)
Post-secondary education	**0.31 (0.10, 0.53)**	0.11 (-0.06, 0.27)	-0.06 (-0.22, 0.09)	-0.06 (-0.25, 0.13)

Table J-2. (Cont'd) Multiple Linear Regression of the Association between Emotional/Informational Support and RAVLT Change Stratified by Age Group

	Age			
	45-54 years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)				
$20,000 - $49,999	-0.09 (-0.34, 0.15)	0.02 (-0.16, 0.19)	-0.03 (-0.21, 0.15)	-0.14 (-0.34, 0.07)
$50,000 - $99,999	-0.05 (-0.28, 0.19)	0.05 (-0.12, 0.23)	0.01 (-0.18, 0.20)	-0.17 (-0.39, 0.05)
$100,000 – $149,999	0.03 (-0.21, 0.27)	0.01 (-0.17, 0.19)	-0.03 (-0.24, 0.18)	-0.05 (-0.31, 0.21)
≥ $150,000	0.01 (-0.24, 0.26)	0.08 (-0.11, 0.27)	0.01 (-0.21, 0.24)	-0.01 (-0.30, 0.29)
Marital status (vs. married/common-law)				
Single, widowed, divorced, separated	-0.05 (-0.15, 0.05)	0.09 (-0.03, 0.20)	-0.04 (-0.20, 0.13)	0.12 (-0.10, 0.34)
Living arrangement (vs. living alone)				
Living with someone	-0.04 (-0.16, 0.08)	0.06 (-0.07, 0.19)	-0.02 (-0.18, 0.14)	0.13 (-0.08, 0.34)
Functional status (vs. no impairment)				
Mild impairment	-0.02 (-0.21, 0.18)	-0.01 (-0.14, 0.13)	0.04 (-0.11, 0.19)	-0.15 (-0.31, 0.01)
Moderate, severe, total impairment	**-0.65 (-1.02, -0.27)**	0.32 (-0.57, 1.21)	-0.09 (-0.69, 0.52)	-0.15 (-0.53, 0.24)
Chronic conditions (vs. no conditions)				
1 chronic condition	0.03 (-0.04, 0.10)	-0.03 (-0.10, 0.04)	0.01 (-0.08, 0.11)	-0.04 (-0.22, 0.13)
2 chronic conditions	0.03 (-0.08, 0.13)	-0.05 (-0.14, 0.04)	-0.06 (-0.16, 0.05)	-0.07 (-0.25, 0.10)
≥ 3 chronic conditions	0.01 (-0.15, 0.17)	-0.02 (-0.12, 0.08)	0.06 (-0.05, 0.17)	-0.00 (-0.19, 0.18)
Depressive symptoms	-0.00 (-0.01, 0.01)	-0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	-0.00 (-0.01, 0.01)
Smoking status (vs. never smoker)				
Former smoker	**0.07 (0.00, 0.14)**	-0.03 (-0.10, 0.03)	0.01 (-0.06, 0.09)	-0.12 (-0.23, 0.00)
Current smoker	0.10 (-0.02, 0.21)	0.01 (-0.11, 0.13)	0.03 (-0.19, 0.25)	0.07 (-0.29, 0.43)
Alcohol use (vs. no alcohol use)				
Occasional use	0.08 (-0.07, 0.22)	0.11 (-0.02, 0.24)	-0.01 (-0.16, 0.15)	**0.26 (0.04, 0.48)**
Regular use	0.04 (-0.06, 0.14)	0.04 (-0.06, 0.14)	-0.04 (-0.16, 0.08)	0.11 (-0.04, 0.26)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values (p<0.05) are bolded

Table J-3. Multiple Linear Regression of the Association between Affectionate Support and RAVLT Change Stratified by Age Group

	Age			
	45-54 years β (95% CI)	55-64 years β (95% CI)	65-74 years β (95% CI)	≥ 75 years β (95% CI)
R^2 Adjusted R^2	0.4878 0.4866	0.4891 0.4879	0.4501 0.4488	0.4236 0.4223
High Affectionate Support (vs. low)	0.03 (-0.11, 0.16)	0.10 (-0.01, 0.21)	-0.08 (-0.23, 0.08)	0.03 (-0.18, 0.24)
Baseline RAVLT	**-1.00** **(-1.03, -0.96)**	**-1.04** **(-1.07, -1.00)**	**-1.02** **(-1.07, -0.98)**	**-1.02** **(-1.09, -0.94)**
Sex (vs. male)				
Female	0.00 (-0.06, 0.07)	0.01 (-0.05, 0.07)	0.03 (-0.05, 0.11)	-0.05 (-0.19, 0.09)
Province (vs. Ontario)				
Alberta	0.06 (-0.06, 0.17)	**-0.13** **(-0.24, -0.02)**	0.05 (-0.10, 0.20)	-0.07 (-0.28, 0.15)
British Columbia	-0.02 (-0.12, 0.08)	**-0.11** **(-0.20, -0.02)**	0.05 (-0.06, 0.16)	-0.03 (-0.19, 0.13)
Manitoba	0.12 (-0.00, 0.23)	-0.04 (-0.16, 0.07)	-0.02 (-0.15, 0.12)	0.02 (-0.19, 0.23)
Newfoundland and Labrador	0.00 (-0.13, 0.13)	0.00 (-0.13, 0.13)	0.10 (-0.06, 0.26)	-0.13 (-0.36, 0.11)
Nova Scotia	0.05 (-0.08, 0.18)	-0.11 (-0.23, 0.01)	0.12 (-0.04, 0.29)	-0.18 (-0.42, 0.05)
Quebec	0.04 (-0.06, 0.14)	**-0.13** **(-0.22, -0.04)**	0.03 (-0.08, 0.14)	-0.13 (-0.30, 0.04)
Education (vs. less than secondary)				
Secondary education	**0.38** **(0.13, 0.63)**	0.14 (-0.05, 0.33)	**-0.19** **(-0.37, -0.01)**	0.08 (-0.16, 0.31)
Some post-secondary education	**0.37** **(0.12, 0.62)**	0.05 (-0.14, 0.25)	-0.07 (-0.27, 0.13)	-0.07 (-0.32, 0.17)
Post-secondary education	**0.32** **(0.10, 0.54)**	0.10 (-0.07, 0.27)	-0.06 (-0.22, 0.09)	-0.06 (-0.25, 0.13)

Table J-3. (Cont'd) Multiple Linear Regression of the Association between Affectionate Support and RAVLT Change Stratified by Age Group

	Age			
	45-54 years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)				
$20,000 - $49,999	-0.09	0.01	-0.02	-0.13
	(-0.34, 0.16)	(-0.16, 0.18)	(-0.21, 0.16)	(-0.34, 0.07)
$50,000 - $99,999	-0.04	0.04	0.01	-0.17
	(-0.28, 0.20)	(-0.13, 0.21)	(-0.18, 0.20)	(-0.38, 0.05)
$100,000 – $149,999	0.03	-0.00	-0.02	-0.04
	(-0.22, 0.28)	(-0.18, 0.18)	(-0.23, 0.19)	(-0.30, 0.21)
≥ $150,000	0.01	0.07	0.02	-0.00
	(-0.24, 0.26)	(-0.12, 0.26)	(-0.20, 0.24)	(-0.30, 0.29)
Marital status (vs. married/common-law)				
Single, widowed, divorced, separated	-0.05	0.10	-0.04	0.12
	(-0.16, 0.05)	(-0.01, 0.22)	(-0.20, 0.12)	(-0.10, 0.34)
Living arrangement (vs. living alone)				
Living with someone	-0.04	0.05	-0.01	0.13
	(-0.17, 0.08)	(-0.08, 0.18)	(-0.17, 0.15)	(-0.08, 0.34)
Functional status (vs. no impairment)				
Mild impairment	-0.02	-0.00	0.04	-0.15
	(-0.21, 0.17)	(-0.13, 0.13)	(-0.11, 0.19)	(-0.31, 0.01)
Moderate, severe, total impairment	**-0.65**	0.32	-0.09	-0.15
	(-1.01, -0.29)	(-0.57, 1.21)	(-0.69, 0.50)	(-0.54, 0.24)
Chronic conditions (vs. no conditions)				
1 chronic condition	0.03	-0.03	0.01	-0.05
	(-0.04, 0.10)	(-0.10, 0.04)	(-0.08, 0.11)	(-0.22, 0.13)
2 chronic conditions	0.02	-0.05	-0.06	-0.08
	(-0.08, 0.13)	(-0.13, 0.04)	(-0.16, 0.05)	(-0.25, 0.10)
≥ 3 chronic conditions	0.01	-0.02	0.06	-0.00
	(-0.15, 0.17)	(-0.12, 0.08)	(-0.05, 0.17)	(-0.18, 0.18)
Depressive symptoms	-0.00	0.00	-0.00	-0.00
	(-0.01, 0.01)	(-0.01, 0.01)	(-0.01, 0.01)	(-0.02, 0.01)
Smoking status (vs. never smoker)				
Former smoker	**0.07**	-0.03	0.01	-0.12
	(0.00, 0.15)	(-0.10, 0.03)	(-0.06, 0.09)	(-0.23, 0.00)
Current smoker	0.10	0.01	0.03	0.07
	(-0.02, 0.21)	(-0.10, 0.13)	(-0.19, 0.24)	(-0.30, 0.43)
Alcohol use (vs. no alcohol use)				
Occasional use	0.08	0.11	-0.01	**0.26**
	(-0.07, 0.22)	(-0.02, 0.24)	(-0.16, 0.15)	**(0.04, 0.48)**
Regular use	0.04	0.04	-0.04	0.12
	(-0.06, 0.14)	(-0.07, 0.14)	(-0.15, 0.08)	(-0.04, 0.27)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Table J-4. Multiple Linear Regression of the Association between Tangible Support and RAVLT Change Stratified by Age Group

	Age			
	45-54years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
R^2	0.4883	0.4889	0.4499	0.4242
Adjusted R^2	0.4871	0.4877	0.4486	0.4229
High Tangible Support (vs. low)	0.12 (-0.01, 0.24)	0.06 (-0.05, 0.16)	-0.02 (-0.14, 0.11)	0.10 (-0.07, 0.27)
Baseline RAVLT	**-1.00 (-1.03, -0.96)**	**-1.04 (-1.07, -1.00)**	**-1.02 (-1.07, -0.97)**	**-1.02 (-1.09, -0.94)**
Sex (vs. male)				
Female	0.01 (-0.06, 0.07)	0.01 (-0.05, 0.07)	0.03 (-0.06, 0.11)	-0.05 (-0.19, 0.09)
Province (vs. Ontario)				
Alberta	0.06 (-0.06, 0.18)	**-0.13 (-0.24, -0.02)**	0.05 (-0.10, 0.20)	-0.07 (-0.28, 0.15)
British Columbia	-0.02 (-0.12, 0.08)	**-0.11 (-0.20, -0.02)**	0.05 (-0.06, 0.16)	-0.03 (-0.19, 0.13)
Manitoba	0.11 (-0.01, 0.23)	-0.04 (-0.16, 0.07)	-0.02 (-0.15, 0.12)	0.02 (-0.19, 0.23)
Newfoundland and Labrador	0.00 (-0.13, 0.130	0.00 (-0.13, 0.13)	0.10 (-0.07, 0.26)	-0.12 (-0.36, 0.11)
Nova Scotia	0.05 (-0.08, 0.18)	-0.11 (-0.24, 0.01)	0.12 (-0.04, 0.29)	-0.18 (-0.42, 0.05)
Quebec	0.04 (-0.06, 0.14)	**-0.13 (-0.23, -0.04)**	0.03 (-0.08, 0.14)	-0.13 (-0.30, 0.04)
Education (vs. less than secondary)				
Secondary education	**0.38 (0.13, 0.63)**	0.14 (-0.05, 0.33)	**-0.19 (-0.37, -0.01)**	0.08 (-0.16, 0.31)
Some post-secondary education	**0.37 (0.12, 0.63)**	0.05 (-0.14, 0.24)	-0.07 (-0.27, 0.13)	-0.06 (-0.31, 0.19)
Post-secondary education	**0.32 (0.10, 0.54)**	0.10 (-0.06, 0.27)	-0.07 (-0.22, 0.09)	-0.06 (-0.24, 0.13)

Table J-4. (Cont'd) Multiple Linear Regression of the Association between Tangible Support and RAVLT Change Stratified by Age Group

	Age			
	45-54 years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)				
$20,000 - $49,999	-0.10 (-0.35, 0.150	0.01 (-0.16, 0.18)	-0.03 (-0.21, 0.15)	-0.13 (-0.33, 0.08)
$50,000 - $99,999	-0.05 (-0.29, 0.19)	0.05 (-0.13, 0.22)	0.01 (-0.18, 0.20)	-0.16 (-0.38, 0.05)
$100,000 – $149,999	0.02 (-0.22, 0.27)	0.00 (-0.18, 0.19)	-0.03 (-0.24, 0.18)	-0.04 (-0.30, 0.22)
≥ $150,000	0.00 (-0.24, 0.25)	0.07 (-0.11, 0.26)	0.02 (-0.21, 0.24)	-0.00 (-0.29, 0.29)
Marital status (vs. married/common-law)				
Single, widowed, divorced, separated	-0.04 (-0.14, 0.06)	0.10 (-0.02, 0.22)	-0.04 (-0.20, 0.12)	0.13 (-0.09, 0.35)
Living arrangement (vs. living alone)				
Living with someone	-0.06 (-0.18, 0.07)	0.05 (-0.07, 0.18)	-0.02 (-0.18, 0.15)	0.12 (-0.09, 0.33)
Functional status (vs. no impairment)				
Mild impairment	-0.01 (-0.20, 0.18)	-0.00 (-0.14, 0.13)	0.04 (-0.11, 0.19)	-0.15 (-0.31, 0.01)
Moderate, severe, total impairment	**-0.64 (-1.02, -0.27)**	0.31 (-0.57, 1.20)	-0.08 (-0.69, 0.52)	-0.15 (-0.55, 0.24)
Chronic conditions (vs. no conditions)				
1 chronic condition	0.03 (-0.04, 0.10)	-0.03 (-0.10, 0.04)	0.01 (-0.08, 0.11)	-0.04 (-0.21, 0.13)
2 chronic conditions	0.02 (-0.08, 0.13)	-0.05 (-0.14, 0.04)	-0.06 (-0.16, 0.05)	-0.08 (-0.25, 0.10)
≥ 3 chronic conditions	0.01 (-0.15, 0.17)	-0.02 (-0.12, 0.08)	0.06 (-0.05, 0.17)	0.00 (-0.18, 0.18)
Depressive symptoms	-0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	-0.00 (-0.01, 0.01)	-0.00 (-0.01, 0.01)
Smoking status (vs. never smoker)				
Former smoker	0.07 (-0.00, 0.14)	-0.03 (-0.10, 0.03)	0.01 (-0.06, 0.09)	-0.11 (-0.23, 0.01)
Current smoker	0.10 (-0.02, 0.21)	0.01 (-0.10, 0.13)	0.03 (-0.19, 0.25)	0.07 (-0.29, 0.43)
Alcohol use (vs. no alcohol use)				
Occasional use	0.08 (-0.06, 0.22)	0.11 (-0.02, 0.24)	-0.01 (-0.16, 0.15)	**0.26 (0.04, 0.48)**
Regular use	0.04 (-0.06, 0.14)	0.04 (-0.07, 0.14)	-0.04 (-0.16, 0.08)	0.11 (-0.04, 0.27)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Table J-5. Multiple Linear Regression of the Association between Positive Social Interactions and RAVLT Change Stratified by Age Group

	Age			
	45-54 years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
R^2	0.4878	0.4889	0.4501	0.4237
Adjusted R^2	0.4866	0.4877	0.4488	0.4224
High Positive Social Interactions (vs. low)	0.00 (-0.12, 0.12)	0.06 (-0.05, 0.17)	0.08 (-0.06, 0.23)	-0.05 (-0.24, 0.14)
Baseline RAVLT	**-1.00 (-1.03, -0.96)**	**-1.04 (-1.07, -1.00)**	**-1.02 (-1.07, -0.98)**	**-1.02 (-1.09, -0.94)**
Sex (vs. male)				
Female	0.01 (-0.06, 0.07)	0.01 (-0.05, 0.07)	0.02 (-0.06, 0.11)	-0.05 (-0.19, 0.09)
Province (vs. Ontario)				
Alberta	0.06 (-0.06, 0.17)	**-0.13 (-0.22, -0.04)**	0.05 (-0.10, 0.20)	-0.06 (-0.28, 0.15)
British Columbia	-0.02 (-0.12, 0.08)	**-0.11 (-0.20, -0.02)**	0.05 (-0.06, 0.15)	-0.03 (-0.19, 0.13)
Manitoba	0.12 (-0.00, 0.23)	-0.04 (-0.16, 0.07)	-0.02 (-0.15, 0.11)	0.02 (-0.19, 0.23)
Newfoundland and Labrador	0.00 (-0.13, 0.13)	0.00 (-0.13, 0.13)	0.10 (-0.07, 0.26)	-0.12 (-0.36, 0.11)
Nova Scotia	0.05 (-0.08, 0.18)	-0.11 (-0.23, 0.01)	0.12 (-0.05, 0.28)	-0.18 (-0.41, 0.05)
Quebec	0.04 (-0.07, 0.14)	**-0.13 (-0.22, -0.04)**	0.03 (-0.08, 0.14)	-0.13 (-0.29, 0.04)
Education (vs. less than secondary)				
Secondary education	**0.38 (0.13, 0.63)**	0.14 (-0.05, 0.33)	**-0.19 (-0.37, -0.01)**	0.08 (-0.16, 0.31)
Some post-secondary education	**0.37 (0.12, 0.63)**	0.06 (-0.14, 0.25)	-0.07 (-0.27, 0.13)	-0.07 (-0.32, 0.17)
Post-secondary education	**0.32 (0.10, 0.53)**	0.10 (-0.06, 0.27)	-0.06 (-0.22, 0.09)	-0.06 (-0.25, 0.13)

Table J-5. (Cont'd) Multiple Linear Regression of the Association between Positive Social Interactions and RAVLT Change Stratified by Age Group

	Age			
	45-54years	55-64 years	65-74 years	≥ 75 years
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)				
$20,000 - $49,999	-0.09 (-0.34, 0.16)	0.01 (-0.16, 0.19)	-0.03 (-0.21, 0.15)	-0.13 (-0.33, 0.08)
$50,000 - $99,999	-0.04 (-0.28, 0.20)	0.05 (-0.13, 0.22)	0.00 (-0.19, 0.19)	-0.16 (-0.38, 0.05)
$100,000 – $149,999	0.03 (-0.21, 0.28)	0.00 (-0.18, 0.19)	-0.03 (-0.24, 0.18)	-0.04 (-0.30, 0.22)
≥ $150,000	0.02 (-0.23, 0.26)	0.07 (-0.11, 0.26)	0.01 (-0.22, 0.23)	0.00 (-0.29, 0.30)
Marital status (vs. married/common-law)				
Single, widowed, divorced, separated	-0.05 (-0.16, 0.05)	0.10 (-0.02, 0.22)	-0.03 (-0.19, 0.14)	0.11 (-0.11, 0.33)
Living arrangement (vs. living alone)				
Living with someone	-0.04 (-0.16, 0.08)	0.06 (-0.07, 0.19)	-0.02 (-0.18, 0.14)	0.13 (-0.08, 0.34)
Functional status (vs. no impairment)				
Mild impairment	-0.02 (-0.21, 0.18)	-0.00 (-0.14, 0.13)	0.04 (-0.11, 0.19)	-0.15 (-0.31, 0.01)
Moderate, severe, total impairment	**-0.66 (-1.01, -0.29)**	0.32 (-0.57, 1.21)	-0.08 (-0.68, 0.52)	-0.16 (-0.55, 0.23)
Chronic conditions (vs. no conditions)				
1 chronic condition	0.03 (-0.04, 0.10)	-0.03 (-0.10, 0.04)	0.02 (-0.08, 0.11)	-0.05 (-0.22, 0.12)
2 chronic conditions	0.02 (-0.08, 0.13)	-0.05 (-0.13, 0.04)	-0.06 (-0.17, 0.05)	-0.08 (-0.25, 0.10)
≥ 3 chronic conditions	0.01 (-0.15, 0.17)	-0.02 (-0.12, 0.08)	0.06 (-0.05, 0.17)	-0.00 (-0.18, 0.18)
Depressive symptoms	-0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	-0.00 (-0.02, 0.01)
Smoking status (vs. never smoker)				
Former smoker	**0.07 (0.00, 0.15)**	-0.03 (-010, 0.03)	0.01 (-0.06, 0.09)	-0.11 (-0.23, 0.00)
Current smoker	0.10 (-0.02, 0.21)	0.01 (-0.10, 0.13)	0.03 (-0.19, 0.25)	0.06 (-0.30, 0.42)
Alcohol use (vs. no alcohol use)				
Occasional use	0.08 (-0.07, 0.22)	0.11 (-0.02, 0.24)	-0.00 (-0.16, 0.15)	**0.26 (0.04, 0.48)**
Regular use	0.04 (-0.06, 0.14)	0.04 (-0.07, 0.14)	-0.04 (-0.16, 0.07)	0.12 (-0.04, 0.27)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Appendix K. Multiple Linear Regression Analysis of the Association between FSS and RAVLT Change Stratified by Sex

Table K-1. Multiple Linear Regression of the Association between Overall FSS and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
R^2	0.4622	0.4956
Adjusted R^2	0.4609	0.4943
High Overall FSS (vs. low)	0.10 (-0.01, 0.22)	-0.01 (-0.13, 0.10)
Baseline RAVLT	**-1.02 (-1.06, -0.99)**	**-1.01 (-1.04, -0.98)**
Age (vs. 45-54 years)		
55-64 years	-0.01 (-0.07, 0.06)	0.00 (-0.06, 0.06)
65-74 years	-0.02 (-0.10, 0.06)	0.00 (-0.07, 0.08)
≥ 75 years	0.02 (-0.09, 0.12)	0.00 (-0.10, 0.11)
Province (vs. Ontario)		
Alberta	0.01 (-0.10, 0.11)	-0.01 (-0.11, 0.09)
British Columbia	0.01 (-0.07, 0.09)	-0.07 (-0.15, 0.01)
Manitoba	0.04 (-0.06, 0.15)	0.05 (-0.04, 0.15)
Newfoundland and Labrador	-0.00 (-0.12, 0.11)	0.03 (-0.08, 0.14)
Nova Scotia	0.02 (-0.09, 0.140	-0.02 (-0.13, 0.09)
Quebec	0.02 (-0.07, 0.100	-0.05 (-0.13, 0.02)
Education (vs. less than secondary)		
Secondary education	**0.21 (0.03, 0.38)**	0.01 (-0.13, 0.15)
Some post-secondary education	0.14 (-0.04, 0.31)	0.04 (-0.10, 0.19)
Post-secondary education	**0.15 (0.01, 0.30)**	0.01 (-0.11, 0.13)

Table K-1. (Cont'd) Multiple Linear Regression of the Association between Overall FSS and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)		
$20,000 - $49,999	-0.14 (-0.35, 0.07)	0.01 (-0.12, 0.13)
$50,000 - $99,999	-0.11 (-0.32,0.09)	0.04 (-0.09, 0.16)
$100,000 – $149,999	-0.08 (-0.29, 0.13)	0.06 (-0.08, 0.20)
≥ $150,000	-0.05 (-0.26, 0.16)	0.06 (-0.09, 0.21)
Marital status (vs. married/common-law)		
Single, widowed, divorced, separated	-0.05 (-0.16, 0.05)	0.03 (-0.06, 0.12)
Living arrangement (vs. living alone)		
Living with someone	-0.08 (-0.20, 0.04)	0.04 (-0.05, 0.14)
Functional status (vs. no impairment)		
Mild impairment	-0.14 (-0.29, 0.00)	0.02 (-0.08, 0.11)
Moderate, severe, total impairment	-0.39 (-1.06, 0.28)	-0.08 (-0.47, 0.31)
Chronic conditions (vs. no conditions)		
1 chronic condition	0.04 (-0.03, 0.10)	-0.02 (-0.08, 0.04)
2 chronic conditions	-0.01 (-0.09, 0.08)	-0.04 (-0.11, 0.04)
≥ 3 chronic conditions	0.07 (-0.02, 0.16)	-0.01 (-0.10, 0.08)
Depressive symptoms	-0.00 (-0.01, 0.00)	0.00 (-0.00, 0.01)
Smoking status (vs. never smoker)		
Former smoker	0.02 (-0.04, 0.08)	0.01 (-0.05, 0.06)
Current smoker	**0.12 (0.01, 0.23)**	-0.01 (-0.11, 0.09)
Alcohol use (vs. no alcohol use)		
Occasional use	0.06 (-0.07, 0.19)	0.09 (-0.01, 0.20)
Regular use	0.04 (-0.05, 0.13)	0.02 (-0.06, 0.10)

FSS: Functional Social Support
β: Rrgression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Table K-2. Multiple Linear Regression of the Association between Emotional/Informational Support and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
R^2	0.4620	0.4956
Adjusted R^2	04607	0.4943
High Emotional/Informational Support (vs. low)	0.03 (-0.08, 0.14)	0.03 (-0.08, 0.13)
Baseline RAVLT	**-1.02 (-1.06, -0.99)**	**-1.01 (-1.04, -0.98)**
Age (vs. 45-54 years)		
55-64 years	-0.01 (-0.07, 0.06)	0.00 (-0.06, 0.06)
65-74 years	-0.02 (-0.10, 0.06)	0.00 (-0.07, 0.08)
≥ 75 years	0.02 (-0.09, 0.12)	0.00 (-0.10, 0.11)
Province (vs. Ontario)		
Alberta	0.00 (-0.10, 0.11)	-0.01 (-0.11, 0.09)
British Columbia	0.01 (-0.07, 0.09)	-0.07 (-0.15, 0.01)
Manitoba	0.04 (-0.06, 0.15)	0.05 (-0.05, 0.15)
Newfoundland and Labrador	-0.00 (-0.12, 0.11)	0.03 (-0.08, 0.14)
Nova Scotia	0.02 (-0.09, 0.14)	-0.02 (-0.13, 0.09)
Quebec	0.02 (-0.07, 0.10)	-0.06 (-0.13, 0.02)
Education (vs. less than secondary)		
Secondary education	**0.21 (0.03, 0.39)**	0.01 (-0.13, 0.15)
Some post-secondary education	0.14 (-0.03, 0.31)	0.04 (-0.10, 0.190
Post-secondary education	**0.16 (0.01, 0.30)**	0.01 (-0.11, 0.13)

Table K-2. (Cont'd) Multiple Linear Regression of the Association between Emotional/Informational Support and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)		
$20,000 - $49,999	-0.13 (-0.34, 0.08)	0.00 (-0.12, 0.13)
$50,000 - $99,999	-0.10 (-0.31, 0.10)	0.03 (-0.09, 0.16)
$100,000 – $149,999	-0.07 (-0.28, 0.14)	0.06 (-0.09, 0.20)
≥ $150,000	-0.04 (-0.25, 0.17)	0.06 (-0.09, 0.21)
Marital status (vs. married/common-law)		
Single, widowed, divorced, separated	-0.06 (-0.17, 0.05)	0.03 (-0.06, 0.12)
Living arrangement (vs. living alone)		
Living with someone	-0.07 (-0.19, 0.05)	0.04 (-0.05, 0.14)
Functional status (vs. no impairment)		
Mild impairment	-0.39 (-1.06, 0.28)	0.02 (-0.08, 0.11)
Moderate, severe, total impairment	-0.14 (-0.29, 0.01)	-0.07 (-0.46, 0.32)
Chronic conditions (vs. no conditions)		
1 chronic condition	0.04 (-0.03, 0.10)	-0.02 (-0.08, 0.04)
2 chronic conditions	-0.01 (-0.09, 0.08)	-0.04 (-0.11, 0.04)
≥ 3 chronic conditions	0.07 (-0.02, 0.16)	-0.01 (-0.10, 0.08)
Depressive symptoms	-0.00 (-0.01, 0.00)	0.00 (-0.00, 0.01)
Smoking status (vs. never smoker)		
Former smoker	0.02 (-0.04, 0.08)	0.01 (-0.05, 0.06)
Current smoker	**0.12 (0.01, 0.23)**	-0.01 (-0.11, 0.09)
Alcohol use (vs. no alcohol use)		
Occasional use	0.06 (-0.07, 0.19)	0.09 (-0.01, 0.20)
Regular use	0.04 (-0.05, 0.13)	0.02 (-0.06, 0.10)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Table K-3. Multiple Linear Regression of the Association between Affectionate Support and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
R^2	0.4620	0.4956
Adjusted R^2	0.4607	0.4943
High Affectionate Support (vs. low)	0.03 (-0.07, 0.14)	0.04 (-0.06, 0.15)
Baseline RAVLT	**-1.02 (-1.06, -0.99)**	**-1.01 (-1.04, -0.98)**
Age (vs. 45-54 years)		
55-64 years	-0.01 (-0.07, 0.06)	0.00 (-0.06, 0.06)
65-74 years	-0.02 (-0.10, 0.06)	0.00 (-0.07, 0.08)
≥ 75 years	0.02 (-0.09, 0.12)	0.00 (-0.10, 0.11)
Province (vs. Ontario)		
Alberta	0.00 (-0.10, 0.11)	-0.01 (-0.11, 0.09)
British Columbia	0.01 (-0.07, 0.09)	-0.07 (-0.15, 0.01)
Manitoba	0.04 (-0.06, 0.15)	0.05 (-0.05, 0.15)
Newfoundland and Labrador	-0.00 (-0.12, 0.11)	0.03 (-0.08, 0.14)
Nova Scotia	0.02 (-0.09, 0.14)	-0.02 (-0.13, 0.090
Quebec	0.02 (-0.07, 0.10)	-0.06 (-0.13, 0.02)
Education (vs. less than secondary)		
Secondary education	**0.21 (0.04, 0.39)**	0.01 (-0.13, 0.15)
Some post-secondary education	0.14 (-0.03, 0.32)	0.04 (-0.10, 0.19)
Post-secondary education	**0.16 (0.01, 0.30)**	0.01 (-0.11, 0.13)

Table K-3. (Cont'd) Multiple Linear Regression of the Association between Affectionate Support and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)		
$20,000 - $49,999	-0.13 (-0.34, 0.08)	0.00 (-0.12, 0.13)
$50,000 - $99,999	-0.10 (-0.31, 0.10)	0.03 (-0.10, 0.16)
$100,000 – $149,999	-0.07 (-0.29, 0.14)	0.05 (-0.09, 0.20)
≥ $150,000	-0.04 (-0.26, 0.17)	0.06 (-0.09, 0.21)
Marital status (vs. married/common-law)		
Single, widowed, divorced, separated	-0.06 (-0.17, 0.05)	0.04 (-0.05, 0.13)
Living arrangement (vs. living alone)		
Living with someone	-0.07 (-0.19, 0.05)	0.04 (-0.05, 0.13)
Functional status (vs. no impairment)		
Mild impairment	-0.14 (-0.29, 0.01)	0.02 (-0.08, 0.11)
Moderate, severe, total impairment	-0.39 (-1.06, 0.28)	-0.07 (-0.46, 0.31)
Chronic conditions (vs. no conditions)		
1 chronic condition	0.04 (-0.03, 0.10)	-0.02 (-0.08, 0.04)
2 chronic conditions	-0.01 (-0.09, 0.08)	-0.04 (-0.11, 0.04)
≥ 3 chronic conditions	0.07 (-0.02, 0.16)	-0.01 (-0.10, 0.08)
Depressive symptoms	-0.00 (-0.01, 0.00)	0.00 (-0.00, 0.01)
Smoking status (vs. never smoker)		
Former smoker	0.02 (-0.04, 0.08)	0.01 (-0.05, 0.06)
Current smoker	**0.12 (0.01, 0.23)**	-0.01 (-0.11, 0.09)
Alcohol use (vs. no alcohol use)		
Occasional use	0.06 (-0.07, 0.19)	0.09 (-0.01, 0.20)
Regular use	0.04 (-0.05, 0.13)	0.02 (-0.06, 0.10)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Table K-4. Multiple Linear Regression of the Association between Tangible Support and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
R^2	0.4623	0.4957
Adjusted R^2	0.4610	0.4944
High Tangible Support (vs. low)	**0.11**	0.06
	(0.01, 0.22)	(-0.03, 0.14)
Baseline RAVLT	**-1.02**	**-1.01**
	(-1.06, -0.99)	**(-1.04, -0.98)**
Age (vs. 45-54 years)		
55-64 years	-0.01	0.00
	(-0.07, 0.06)	(-0.06, 0.06)
65-74 years	-0.02	0.00
	(-0.10, 0.06)	(-0.07, 0.08)
≥ 75 years	0.02	0.00
	(-0.09, 0.12)	(-0.10, 0.11)
Province (vs. Ontario)		
Alberta	0.01	-0.01
	(-0.10, 0.11)	(-0.11, 0.090
British Columbia	0.01	-0.07
	(-0.07, 0.09)	(-0.15, 0.01)
Manitoba	0.04	0.05
	(-0.06, 0.15)	(-0.04, 0.15)
Newfoundland and Labrador	-0.01	0.03
	(-0.12, 0.11)	(-0.08, 0.14)
Nova Scotia	0.02	-0.02
	(-0.09, 0.14)	(-0.13, 0.09)
Quebec	0.01	-0.06
	(-0.07, 0.10)	(-0.14, 0.02)
Education (vs. less than secondary)		
Secondary education	**0.21**	0.01
	(0.04, 0.39)	(-0.13, 0.15)
Some post-secondary education	0.14	0.01
	(-0.03, 0.31)	(-0.13, 0.15)
Post-secondary education	**0.16**	0.04
	(0.01, 0.30)	(-0.10, 0.19)

Table K-4. (Cont'd) Multiple Linear Regression of the Association between Tangible Support and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)		
$20,000 - $49,999	-0.14 (-0.35, 0.07)	0.00 (-0.12, 0.13)
$50,000 - $99,999	-0.11 (-0.31, 0.09)	0.03 (-0.10, 0.16)
$100,000 – $149,999	-0.08 (-0.29, 0.13)	0.05 (-0.09, 0.20)
≥ $150,000	-0.05 (-0.26, 0.16)	0.06 (-0.09, 0.21)
Marital status (vs. married/common-law)		
Single, widowed, divorced, separated	-0.05 (-0.16, 0.06)	0.04 (-0.05, 0.13)
Living arrangement (vs. living alone)		
Living with someone	-0.09 (-0.21, 0.03)	0.04 (-0.06, 0.13)
Functional status (vs. no impairment)		
Mild impairment	-0.14 (-0.29, 0.01)	0.02 (-0.08, 0.11)
Moderate, severe, total impairment	-0.39 (-1.06, 0.28)	-0.08 (-0.47, 0.31)
Chronic conditions (vs. no conditions)		
1 chronic condition	0.04 (-0.03, 0.10)	-0.02 (-0.08, 0.04)
2 chronic conditions	-0.01 (-0.09, 0.08)	-0.04 (-0.11, 0.04)
≥ 3 chronic conditions	0.07 (-0.02, 0.16)	-0.01 (-0.10, 0.08)
Depressive symptoms	-0.00 (-0.01, 0.00)	0.00 (-0.00, 0.01)
Smoking status (vs. never smoker)		
Former smoker	0.02 (-0.04, 0.08)	0.01 (-0.05, 0.06)
Current smoker	**0.12 (0.01, 0.23)**	-0.01 (-0.11, 0.09)
Alcohol use (vs. no alcohol use)		
Occasional use	0.06 (-0.07, 0.19)	0.09 (-0.01, 0.20)
Regular use	0.04 (-0.05, 0.13)	0.02 (-0.06, 0.10)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values ($p<0.05$) are bolded

Table K-5. Multiple Linear Regression of the Association between Positive Social Interactions and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
R^2	0.4621	0.4956
Adjusted R^2	0.4608	0.4943
High Positive Social Interactions (vs. low)	0.06 (-0.04, 0.16)	-0.00 (-0.10, 0.10)
Baseline RAVLT	**-1.02 (-1.06, -0.99)**	**-1.01 (-1.04, -0.98)**
Age (vs. 45-54 years)		
55-64 years	-0.01 (-0.07, 0.06)	0.00 (-0.06, 0.06)
65-74 years	-0.02 (-0.10, 0.06)	0.00 (-0.07, 0.08)
≥ 75 years	0.02 (-0.09, 0.12)	0.00 (-0.10, 0.11)
Province (vs. Ontario)		
Alberta	0.01 (-0.10, 0.11)	-0.01 (-0.11, 0.09)
British Columbia	0.01 (-0.07, 0.09)	-0.07 (-0.15, 0.01)
Manitoba	0.04 (-0.06, 0.15)	0.05 (-0.04, 0.15)
Newfoundland and Labrador	-0.00 (-0.12, 0.11)	0.03 (-0.08, 0.14)
Nova Scotia	0.02 (-0.09, 0.14)	-0.02 (-0.13, 0.09)
Quebec	0.02 (-0.06, 0.10)	-0.06 (-0.13, 0.02)
Education (vs. less than secondary)		
Secondary education	**0.21 (0.03, 0.39)**	0.01 (-0.13, 0.15)
Some post-secondary education	0.14 (-0.04, 0.31)	0.04 (-0.10, 0.19)
Post-secondary education	**0.15 (0.01, 0.30)**	0.01 (-0.11, 0.13)

Table K-5. (Cont'd) Multiple Linear Regression of the Association between Positive Social Interactions and RAVLT Change Stratified by Sex

	Sex	
	Male	Female
	β (95% CI)	β (95% CI)
Annual household income (vs. ≤ $19,999)		
$20,000 - $49,999	-0.13 (-0.34, 0.08)	0.00 (-0.12, 0.13)
$50,000 - $99,999	-0.11 (-0.31, 0.10)	0.04 (-0.09, 0.16)
$100,000 – $149,999	-0.08 (-0.29, 0.13)	0.06 (-0.09, 0.20)
≥ $150,000	-0.04 (-0.26, 0.17)	0.06 (-0.09, 0.21)
Marital status (vs. married/common-law)		
Single, widowed, divorced, separated	-0.06 (-0.17, 0.05)	0.03 (-0.06, 0.12)
Living arrangement (vs. living alone)		
Living with someone	-0.07 (-0.19, 0.05)	0.04 (-0.05, 0.14)
Functional status (vs. no impairment)		
Mild impairment	-0.14 (-0.28, 0.01)	0.02 (-0.08, 0.11)
Moderate, severe, total impairment	-0.38 (-1.03, 0.28)	-0.08 (-0.47, 0.31)
Chronic conditions (vs. no conditions)		
1 chronic condition	0.03 (-0.03, 0.10)	-0.02 (-0.08, 0.04)
2 chronic conditions	-0.01 (-0.09,0.08)	-0.04 (-0.11, 0.04)
≥ 3 chronic conditions	0.07 (-0.02, 0.16)	-0.01 (-0.10, 0.08)
Depressive symptoms	-0.00 (-0.01, 0.00)	0.00 (-0.00, 0.01)
Smoking status (vs. never smoker)		
Former smoker	0.02 (-0.04, 0.08)	0.01 (-0.05, 0.06)
Current smoker	**0.12 (0.01, 0.23)**	-0.01 (-0.11, 0.09)
Alcohol use (vs. no alcohol use)		
Occasional use	0.06 (-0.07, 0.19)	0.09 (-0.01, 0.20)
Regular use	0.04 (-0.05, 0.13)	0.02 (-0.06, 0.10)

β: Regression coefficient; CI: Confidence Interval
Statistically significant values (p<0.05) are bolded